# ENGINEERING HERITAGE AUSTRALIA (VICTORIA)

# PLAQUING NOMINATION ASSESSMENT FORM

## 1.BASIC DATA

**Item Name:** Cassilis Hydro-Electric Power Scheme

**Other Name:** Cassilis Gold Mining Company Power Station, Cobungra

**Location:** Grid Ref 55HEU, 378945 to 404967

**Address:** Victoria Falls Road, off the Great Alpine Road, Cobungra, Vic

**Nearest Town:** Omeo

**State:** Victoria

**Local Gov't Area:** Shire of Omeo

**Owner:** State of Victoria. Managed by Parks Victoria

**Current Use:** Designated Historic Area

**Former Use:** Hydro-electric power scheme to supply the Cassilis Gold Mining Company mine and works at Tongio West

**Designer:** Francis Coote M.E.

**Maker/ Builder:**
Mephan Ferguson (pipeline)
Voith (water turbines)
A.E.G. (electrical plant)
Cassilis Gold Mining Co. (water race, transmission line)

**Year Started:** 1907 **Year Completed:** 1908

**Physical Description:**

As built in 1907/1908 the scheme comprised a small diversion weir across the Victoria River feeding a 5km water race terminating in a small forebay. From here the water entered a 450m steel pipeline leading down 120m to the power station beside the Cobungra river. A 670HP Pelton wheel drove the single 500kVA alternator, and a 17HP Pelton wheel drove a 10kW dc auxiliary generator. The 3-phase output was stepped up to 12kV for transmission 24km to the mine and treatment works at Tongio West.

**Physical Condition:**

After closure of the mine in 1916 all the hydro-electric plant was moved to Magnet in Tasmania. The remains still on site in East Gippsland, Victoria comprise:

1. The ends of the short lived earth storage dam built across the Victoria River in 1916;
2. The 5km water race, converted to an unsealed tourist road in 1965;
3. The forebay at the end of the water race;
4. The concrete inlet structure including the first tapered steel pipe;
5. The remains of the trench which housed the 450m long steel pipeline;
6. The concrete floor of the power station beside the Cobungra River, with the three concrete cubicles which contained the surge diverters.

Following recommendations from the Land Conservation Council, Victoria, Historic Areas have been created at the power scheme site and at the Cassilis mines and treatment works. These are managed by Parks Victoria, and an interpretive sign has been set up next to the Victoria River where the water race started.

**Modifications and Dates:**

The scheme suffered from water shortages each summer, and finally early in 1916 an earth wall was constructed across the Victoria River to provide a small storage dam. Due to poor construction this washed

away in June 1916, and 3 months later the mine closed. All the machinery, the pipeline and the transmission line were then sold at auction and removed.

**Historical Notes:**

By 1905 the Cassilis Gold Mining Company was having difficulty obtaining sufficient wood to fire its boilers and roasting furnaces, and the situation was getting worse each year. The bold solution to this problem was to convert the mechanical drives from steam to electric power, to be supplied by a new hydro-electric scheme. The Victoria River falls 120m in the last few kilometres before it joins the Cobungra River, and the mine manager, Francis James Coote, planned the scheme on the Victoria rather than the larger but less steeply falling Cobungra River. Annual Reports claim that the company obtained water rights over both rivers, sufficient to generate the ultimate planned 800kW at 120m head. No records have been found of any stream flow measurements made by Mr Coote, a qualified surveyor.

The Tender Specification issued in March 1907 is quite detailed and may have drawn on previous specifications for other schemes. By 1906 several significant hydro-electric plants were operating in New Zealand, and the Duck Reach (Launceston) plant started in 1895. No significant hydro plants had been built in Victoria, but two had been built near Hillgrove NSW based on the Gara and Styx Rivers. These last two supplied local mines and so Mr Coote would probably have been aware of them and able to obtain full details.

Mr Coote gave a copy of the Tender Specification to his assistant, John Avery, a qualified chemist with some engineering training. This copy has survived, and with extensive annotations by John Avery it has been a major source of information about the scheme, including such things as the itemised quotes received from seven of the leading world manufacturers.

The plant chosen was certainly of first class standard, as was the Mephan Ferguson pipeline. All the material had to be transported about 160km from Bairnsdale

railway station to the Cobungra River site, much of the route on rough tracks. The 5km water race had to be dug by hand and the 24km transmission line route cleared, poles erected and wires strung. To complete the scheme in 18 months was a remarkable achievement, particularly considering the remote location and the alpine weather conditions.

Unfortunately the 1908/9 summer flow in the Victoria River was insufficient to generate the required power, and the mine had to lay off staff. In the Company's February 1909 Report this was blamed on "an unusually dry summer", and the construction of a large storage dam was foreshadowed.

By August the rains had come and the dam was no longer considered necessary. This 6-monthly swing was repeated each year, and it is hard to understand the failure of the Cassilis Company Board to face reality. Many solutions were possible as well as the proposed storage dam (which modern calculations show would have been inadequate). The Cobungra River could have been tapped, or alternative steam drives could have been re-installed for summer use. The only action finally taken was to build a small storage dam in 1916 at the race intake, and this was so poorly constructed that it washed away in a few months.

The annual shortages of power are often blamed for the closure of the mine, but there were other contributing causes. The Cassilis ores are still considered among the most difficult to treat, and frequent changes of process and manager added to costs. As with all mines the increasing depth raised the winding and drainage costs, and the 1914-18 war led to a shortage of labour. Even without the hydro-electric scheme the mine may have closed due to the increasing cost of firewood.

**Heritage Listings:**

Following a 1979 study by the Land Conservation Council Victoria, the "Victoria Falls Historic Area" was created, now managed by Parks Victoria. This 100ha area encompasses the dam, race, forebay, and power station site.

## 2. ASSESSMENT OF SIGNIFICANCE

**Historic Phase:**

The primary significance of this scheme was that it was the first such work in Victoria, built some 20 years before the first comparable SECV hydro-electric scheme at Rubicon Falls.

**Historic Individuals or Association:**

None of the people associated with this scheme became famous subsequently.

**Creative or Technical Achievement:**

Faced with the increasing cost and scarcity of firewood the decision to convert the mine and treatment works drives to hydro-electric power was a bold one, although insufficient attention was given to the quantity of water available in summer. The plant was of a very high standard, being chosen from tenders received from leading world manufacturers. The completion of the scheme in 18 months from the issue of the tender to commercial operation was a remarkable achievement considering the remote location and the alpine weather conditions.

**Research Potential:**

Initial research on the scheme was done by McCutchan and Sumner when the area was being assessed in 1979 by the Land Conservation Council, Victoria. Scope for further research into many aspects of the scheme is provided by the large quantity of original documentation which has survived, including -

1. A copy of the 1907 Tender Specification with many annotations by John Avery, who was employed by the Cassilis company during the construction of the power station.
2. Loose technical documents, engineering drawings and wiring diagrams for the plant, which were saved by the Avery family.
3. About 65 half plate (164 x 120mm) glass negatives taken by John Avery showing all stages of construction

of the water race, power station and transmission line.
4. John Avery's album of prints from most of these negatives.
5. The full text of a detailed technical talk describing the scheme, written in 1909 by Harold J. Wright, an electrical engineer employed by the Contractor to erect and commission the plant.
6. John Avery's letter book - June 1899 to August 1909 covering his association with the Cassilis Company.
All this material forms part of the Avery Collection held for future study and research in the Special Collections (Archives Section) of the Baillieu Library, The University of Melbourne.
Being the biggest employer in the district there are many references to the Cassilis company mine in contemporary local newspapers held in the La Trobe Library, State Library of Victoria, as well as periodic reports in mining journals such as the Australian Mining and Engineering Review.

**Social:** Fairweather's 1975 book (see References below) contains many interesting stories about life at the mine, gathered from interviews and the local newspapers.

**Rarity:** There can only be one "first" Victorian hydro-electric scheme, and this is it. The table below lists various schemes proposed by "private" interests, some of which were actually built. Even the first "public" (State Electricity Commission of Victoria) scheme 18 years later had a smaller capacity than Cassilis, which was not exceeded until 1928.

HYDRO-ELECTRIC SCHEMES IN VICTORIA

| ACTUALLY BUILT | kW | PROPOSED |
|---|---|---|
| 1908 **Cassilis** | 400 | 1892 Warrandyte etc. |
| 1911 Warburton | c.20 | 1896 Walhalla |
| 1916 Toora/Foster | c.40 | 1896 Creswick |
| 1916 Yarram | 100 | 1904 Dight's Falls |
| 1918 Noojee | 160 | 1908 Trawool (9MW) |
| 1926 Rubicon Falls (SECV) | 300 | 1911 Beechworth |
| 1928 Rubicon /Royston | 12,700 | 1918 Healesville |

**Representativeness:**

At the time of its construction the station plant and pipeline were state of the art technology, particularly the two hydraulic turbine governers and the alternator voltage regulator.

**Integrity/Intactness:**

The only remnants still on site are the ends of the small storage dam, the forebay with the concrete intake structure, and the power station foundations. The former water race was converted into a tourist road in 1965.

**References:**

McCutchan J. and Sumner R. : A Pioneer Hydro-Electric Scheme. Conference Papers "Engineering in the 80s", pp7-12. The Institution of Engineers, Australia , April 1980

Allison A. : The Cassilis Hydro-Electric Plant. The Mining and Engineering Review Vol 3, 5th April 1911, pp291-297.

Fairweather K. McD. : Time to Remember. James Yeates, Bairnsdale 1975

The primary source material forms part of the Avery Collection in the Special Collections (Archives Section), Baillieu Library, The University of Melbourne.
Written material and photographs covering the subsequent operation of the plant at Magnet, Tasmania have been deposited with the Hellyer Library, Burnie Tasmania.

**Statement of Significance:**

The primary significance of this scheme was that it was the first hydro-electric scheme in Victoria, built some 20 years before the first comparable SECV scheme at Rubicon Falls.

**Assessed Significance:** State

**Images and Captions:**

About 65 photographs taken by John Avery during the 1907/1908 construction are available. These cover
- digging the water race
- transporting the machinery
- the completed forebay
- installing the pipeline
- erecting the plant
- views of the completed plant
- external view of the power station
- erecting the transmission line
- part of the completed line

Modern (post 1978) photographs have been taken by John McCutchan.

The following captions apply to 11 selected pictures.

1 A bullock team transporting plant 160km from Bairnsdale railway station to the Cobungra River site.
2 The 24km transmission line route crossing the Great Dividing Range.
3 The 5km water race.
4 Lowering the rivetted steel pipeline from the forebay.
5 The 670HP turbine and flywheel during erection.
6 The completed plant: 670HP turbine / 500kVA alternator at the rear; 17HP turbine / 10kW auxiliary generator at the front; HV step-up transformers at far right.
7 The line surge diverters in their concrete cubicles.
8 The Voith hydraulic governor for the 670HP turbine.
9 The marble switchboard. Tirrell voltage regulator on the left panel; measuring and recording instruments, overload relays, and HV circuit breaker operating wheel on the centre panel; dc auxiliary generator controls on the right panel.
10 The completed power station, 1908
11 1979 photo from the same viewpoint

## 3. PROPOSED PLAQUE WORDING

In 1908 the Cassilis Gold Mining Company built Victoria's first significant hydro-electric scheme on this site. It was designed by the mine manager, Francis James Coote, to provide 400kW to the company's mine and treatment works at Tongio West, to reduce the need for expensive firewood. The power was carried by a 12kV transmission line 24 km long, crossing the Great Dividing Range. After the mine closed in1916 the plant was moved to Magnet in Tasmania where it ran until 1940.

## Appendix A Plaque Nomination Form

The Administrator
Engineering Heritage Australia
Engineers Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of work: **The Cassilis Hydro-electric Scheme, Cobungra**

The above-mentioned work is nominated to be awarded an **Historic Engineering Marker**

Location: including address and map grid reference if a fixed work:

**Victoria Falls Road, off the Great Alpine Road, Cobungra in the State of Victoria. The Victoria Falls Historic Area extends from AMG 55HEU 378945 to 404967**

Owner (name & address): **Managed by Parks Victoria for the State of Victoria**

The owner has been advised of this nomination and a letter of agreement is attached.

Access to site: A public road (Victoria Falls Road) runs through the Historic Area, along a former water race. A foot track leads down to the power station site beside the Cobungra River

Nominating Body: Engineering Heritage Victoria

**John C McCutchan**

**Proponent**

Date: 5 November 2007

Donald W Bartlett

Chairman of Engineering Heritage Victoria

Date: 5 November 2007

ENGINEERS AUSTRALIA

ENGINEERING HERITAGE VICTORIA

*A Special Interest Group of the Victorian Division of*

**Engineers Australia**
*and the*
**Institution of Engineers [Australia]**

Our File : Parks Victoria Cassilis 070210
10 February 2007

Mr David Foster
Chief Ranger
Parks Victoria
PO Box 206
OMEO, Victoria, 3898

Dear Mr Foster

**Re : Engineering Heritage - Recognition of Cassilis Hydro Scheme**

Further to your recent discussions with Mr John McCutchan, I confirm that Engineering Heritage Victoria is in the process of nominating the above scheme for recognition under the National Engineering Plaquing Program run by the Institution of Engineers (Australia) through Engineering Heritage Australia.

At this early stage, we need your cooperation in one matter. Our guidelines prescribe that the owner of the land or artefact to be plaqued must offer "no objection" to the proposal. I understand that you have discussed this aspect with John and I now seek your written advice that Parks Victoria will offer "no objection" to the proposal. A copy of the Draft Nomination is attached for your information.

If you have any queries or wish to discuss this matter further, please do not hesitate to contact me at my business office – 03 9725 6299 (phone and fax) or Mobile 0418 559 779. My postal address is PO Box 990 Croydon, Victoria, 3136 and private email is donb@consuleng.com.au.

Yours sincerely,

DONALD W (DON) BARTLETT
CHAIRMAN

**Parks VICTORIA**

Telephone: 03 5159 0608
Mobile: 0427 [illegible]
[illegible]
A B N 95 337 637 697

**19 February 2007**

**Mr Donald Bartlett**
**Engineering Heritage Victoria**
**PO Box 990**
**CROYDON**
**VICTORIA 3136**

Dear Mr Bartlett

**Re: Engineering Heritage – Recognition of Cassilis Hydro – Electric Power Scheme**

Thank you for your letter of 10 February 2007 regarding recognition of the Cassilis Hydro – Electric Power Scheme.

I am writing to confirm that Parks Victoria has no objection to the installation of a plaque at the site of the Cassilis Hydro – Electric Power Scheme recognising the centenary of the scheme and the valuable contribution that this structure played in the early "engineering history" of Victoria.

I have spoken with Mr John McCutchan about the proposal and fully support his push to have this important structure recognised.

I have read the proposed wording for the plaque and agree with the content. I hope that there will be adequate space for a photo of the plant and workings.

Should you wish to further discuss the proposal please contact me at my office on 0351590608 or mobile 0427 8079113.

Yours sincerely

David Foster
Ranger in Charge
Eastern Alps Unit
Alpine National Park

Healthy Parks Healthy People

# The Cassilis Hydro-Electric Plant

Description of the Installation, Together with Some Tests Recently Carried Out.

By A. Allison, A.M. Am. I.E.E.

The hydro-electric plant of the Cassilis Gold Mining Company, Gippsland, Victoria, is one of the few installations of any magnitude in Australia. The plant was installed for the purpose of giving cheaper power to operate the company's mines and works, replacing, as it did, a steam plant previously in use. This latter had entailed a heavy expenditure, and was responsible for a fuel bill of £500 per month. The ores being of a refractory nature, the profits of the company were seriously affected by the power question alone. The power station is situated in a remote and inaccessible part of Gippsland, some nine miles from Omeo, on the Cobungra River, about a quarter of a mile above its junction with the Victoria River. The water for the plant is obtained from the Victoria about four miles above the junction, full advantage being taken of the Victoria Falls, which enable a working head of 410 feet to be obtained, with a race 3½ miles long. This race has a cross section of 15½ square feet, and a grade of 10 feet to the mile, and is capable of delivering 40 cubic feet per second. It terminates in a pressure dam, 1 chain by 1½ chains by 9 feet deep, which allows the sand in suspension in the water to settle before the water enters the pipe column. The latter is 1650 feet long, and has an average diameter of 31 inches. It is made up of malleable steel piping, and reduces in three steps of equal length from 34 inches to 31 inches to 28 inches diameter. It has a factor of safety of 4.

General View Cassilis Mine Plant.

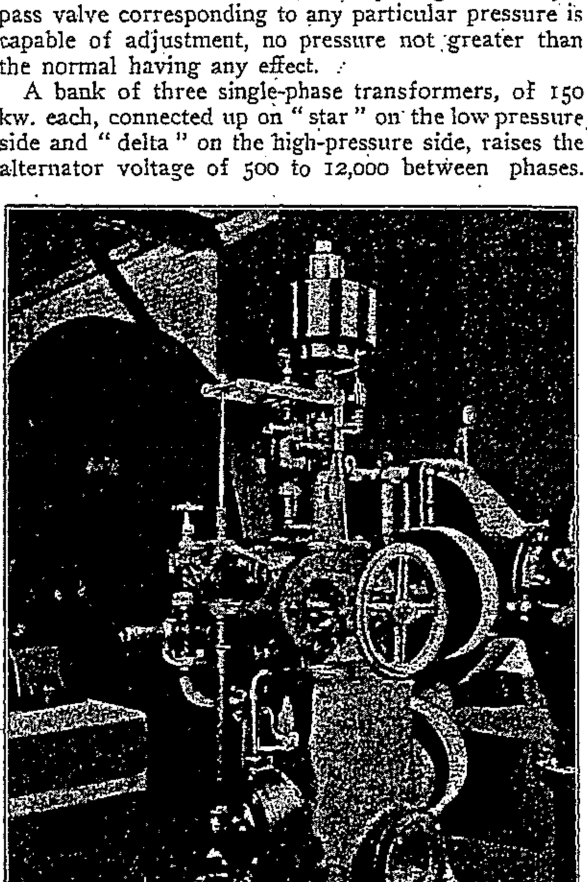
The power station plant, which is designed for double its present capacity, consists of a Voith's pelton wheel, having a capacity of 670 b.h.p., running at 500 revolutions per minute, coupled through a flexible coupling to an A.E.G. 3-phase generator of 500 k.v.a. normal capacity, and is capable of maintaining an overload of 25 per cent. for a short time. The exciter is mounted on the main shaft. There is also a separate exciter set, with turbine and governors complete, of 10 kw. capacity, to act as a spare exciter, and supply the station and local lighting. The main turbine has two nozzles playing the water tangentially on to the pelton wheel, these being opened or closed by the

governors, according to the load. Thus, for all loads, a maximum saving of water is effected. The governing is carried out hydraulically, or, rather, by oil, since the movement of the piston operating the gates of the nozzles is produced by oil under a pressure of 10 atmospheres. The system of governing by oil pressure is a decided improvement on that done by water, as, even when the water is filtered, it is not an uncommon thing for grit to get into the valves, and so upset the working of the governors. Their action may be seen from the following sketches:—

Referring to Fig. 1, 10 is a rotary pump pumping the oil into the pressure chamber 8, which is kept about half full, so that the resilience of the air confined in the chamber will be sufficient to keep the working pressure constant under working conditions. A spring relief, or safety valve (15) keeps the pressure at 10 atmospheres, and allows the oil in excess of that used by the governor to leak back into the oil tank (9). The centrifugal force of the weights (18) of the governor is counterbalanced by the spring (27) which controls, by its setting, the degree of stability or sensitiveness of the governor. In Fig. 3 is shown in detail the relay piston valve controlling the ports of the main cylinder (5, Fig. 1). The oil under pressure leaks through the central portion of the spindle valve to the top and bottom of the piston valve (55), the pressure being constant on either side as long as the spindle valve remains in a definite position. A movement of 1-32 inch up or down is sufficient to close or open the exhaust on the bottom side of the piston valve, so that the piston valve moves accordingly up or down, as the equilibrium of the pressures are upset. This, in turn, opens or closes the main ports. The central fulcrum (38) is capable of being screwed up or down by hand, and consequently decides the speed at which the machine will run. To prevent racing or hunting of the machine, the central fulcrum moves with the rise or fall of the sliding sleeve (51) of the governor, so that the action of the governor is always being neutralised thereby. The movement of this fulcrum is effected through the arm (6), by which it is attached to the main piston. With this arrangement, the machine would govern sluggishly, were it not that the relative movement of the fulcrum (38) is allowed to slip behind that of the arm (6), the connection between the two being through the spring (44) and the amount of slip being controlled by means of the oil dash pot (29). The governor then responds quickly, and is very sensitive to any sudden or great change in speed. The valve (31) allows the oil to escape, and in turn is controlled at the top by the weight (39). With the present setting there is no tendency to hunt; the maximum variation above and below the normal speed is not more than 1½ per cent.

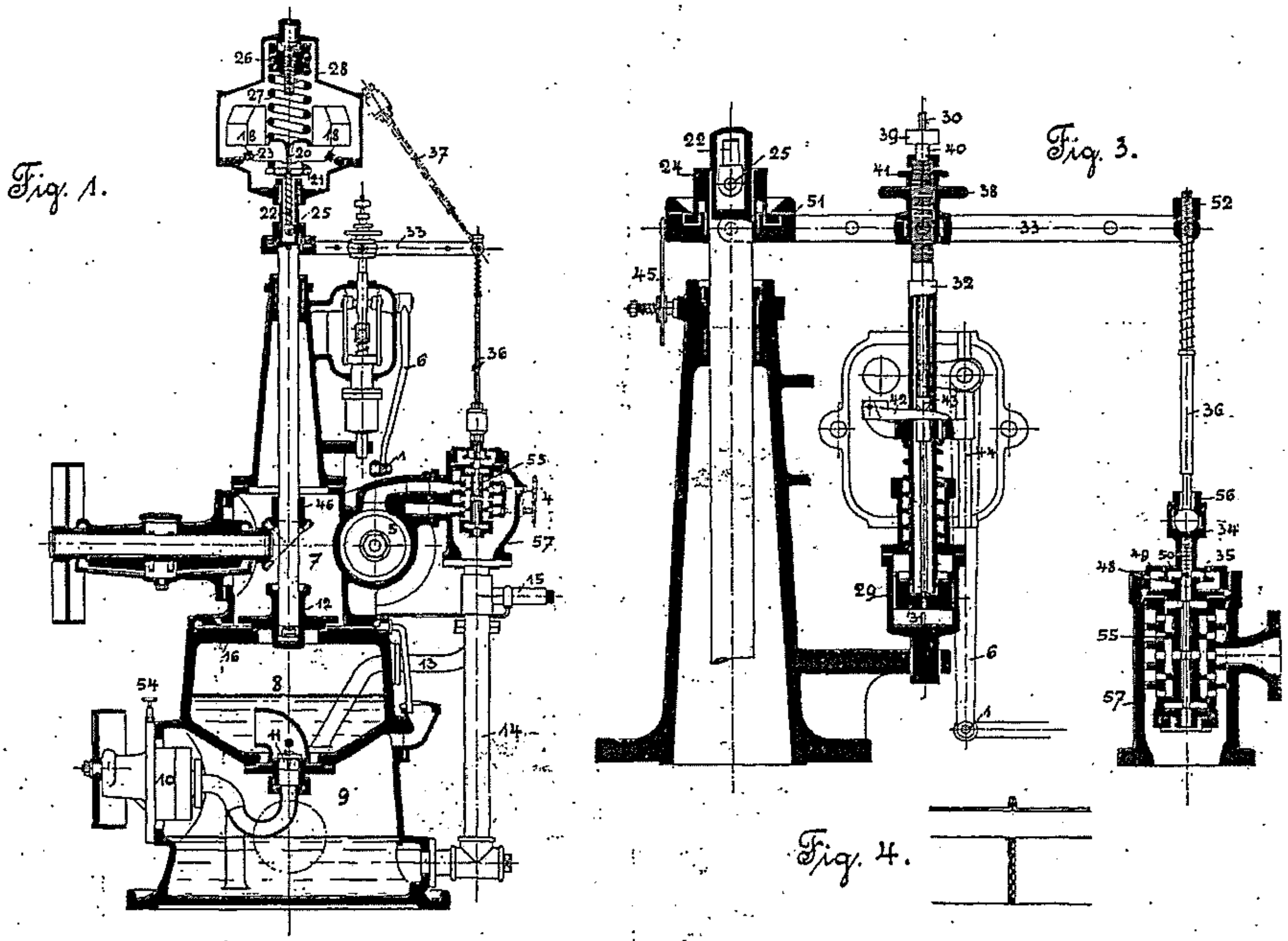
The governor is both sensitive and powerful. The time intervening between a change of the load and when the gates of the turbine starts to open or close to suit that load is three seconds. Should the water be shut off suddenly, due to the load going off rapidly, a bye-pass valve opens and allows the water to escape, thus relieving the column of excessive pressure due to water hammer. The amount of opening of the bye-pass valve corresponding to any particular pressure is capable of adjustment, no pressure not greater than the normal having any effect.

A bank of three single-phase transformers, of 150 kw. each, connected up on "star" on the low pressure side and "delta" on the high-pressure side, raises the alternator voltage of 500 to 12,000 between phases.

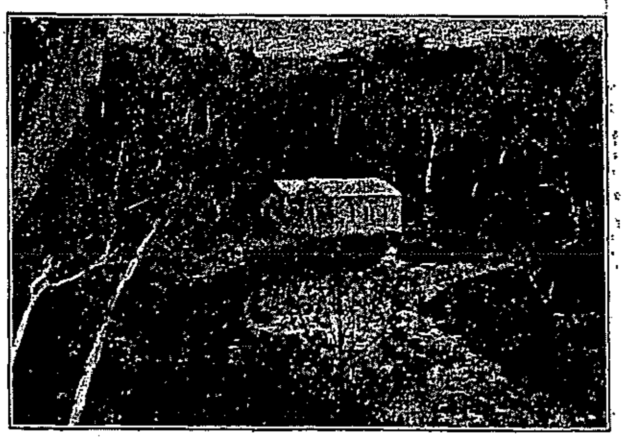


OIL GOVERNOR.

The switchboard has all the necessary gear for switching and regulating the supply of power. For the control of the voltage, a Tirrill regulator is employed, and has proved a very necessary adjunct for the good working of the system. When working without it in circuit, great difficulty is found in operating the hoist motors, and even when close hand regulation is attempted, the voltage is unsatisfactory. This regulator has done duty month in and month out without "sticking up" or losing the voltage, and holds the pressure at the terminals of the largest motor (300 h.p.) well within 2 per cent. of the normal working pressure. The surging experienced by some operators is the re-




Oil Governors.

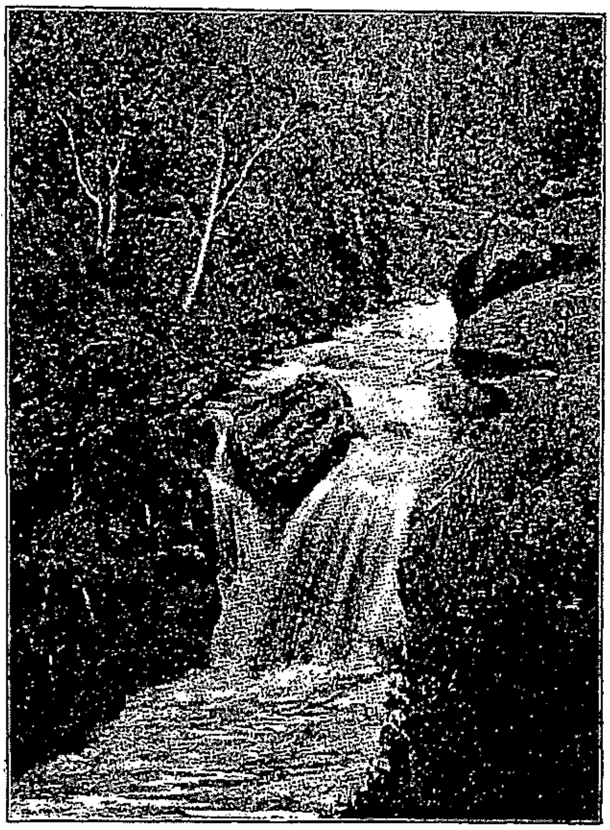


Power Station at Cobungra.

Main Set 670 h.p. Pelton Well and 500 k.v.a. Generator.

sult of improper adjustment and attention, and the unjust accusation that has sometimes been made of this regulator being still in its experimental stage, is usually due to carelessness or ignorance on the part of those concerned. With proper adjustment and a reasonable amount of attention, there should be little or no trouble.

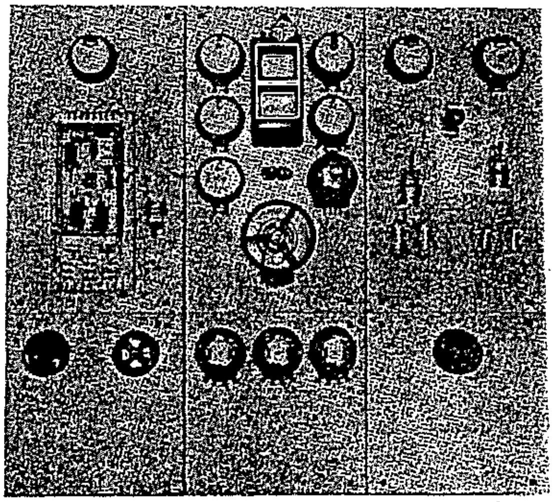
The energy is transmitted to two sub-stations—one at the works and the other at the mine. The former is equipped with 3 single-phase transformers of 125 kw. each—for reducing the voltage from 12,000 to



Portion of Victoria Falls.

550—together with a high-tension switch and a low-tension switchboard of 6 panels. The latter is similarly equipped, except that the transformers are of only 35 kw. capacity each. Spare transformers are kept at all stations. The loading on these sub-stations consists of (1) a two-stage high-speed compressor built by Bellis and Morcom, with a capacity of 1600 cubic feet of free air per minute, compressing to 110 lbs. per square inch. This is driven by a motor of 300 h.p. running at 300 revs. per minute, to which it is connected by a flexible coupling. (2) For the operation of the battery, winches and suction pumps, two 75 h.p. motors are required; while (3) for the workshop, agitators, stone breaker and filter press, motors of 15 h.p. are sufficient. Besides these, six 2 h.p. motors are used for blasts, etc. All the motors are designed for 550 volts, and for lighting small transformers reduce the voltage from 550 to 110.

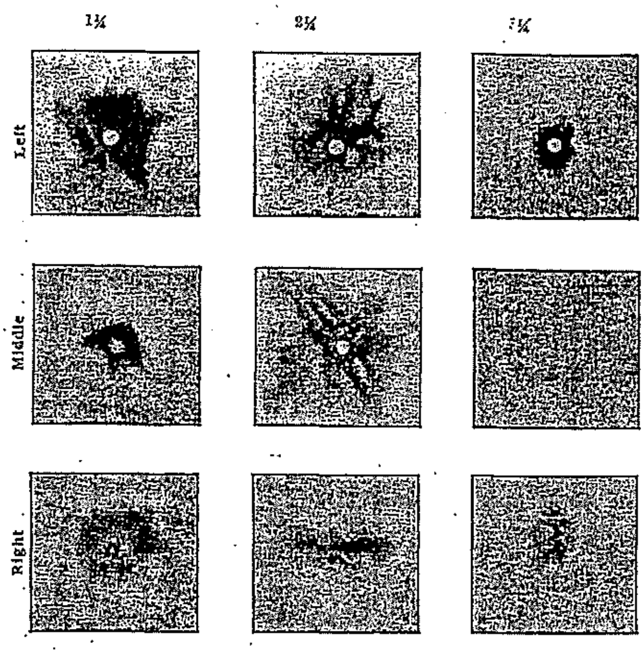
The transmission line is 16½ miles long, and consists of three No. 5 A.W.G. or B. and S.G. hard-drawn solid copper wires, spaced 5 feet apart from each other at the apices of an equilateral triangle. The poles occur at intervals of 160 feet, and the insulators are of white porcelain, tested to withstand 80,000 volts. With full load of 400 kw. at .80 p.f., the ratio of the loss of power to power supplied is 11.8 per cent., and that of pressure drop to pressure delivered is 9.75 per cent. The line pressure at present is 12,000 volts between phases, but in the event of the duplication of the plant, the voltage can be raised to 21,000 volts between phases

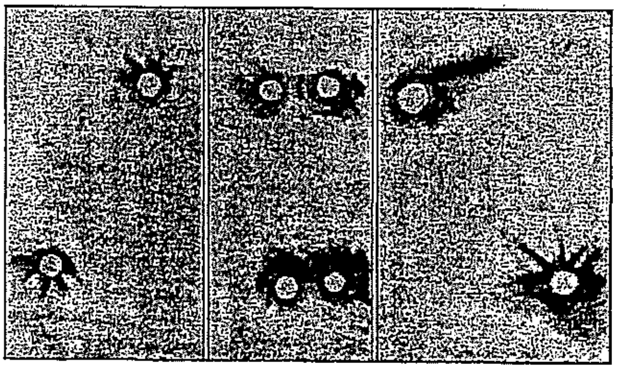


Power Station Switchboard.

by connecting the high-tension side of the transformers in "star" instead of "delta," as at present. Transmitting, then, with double the amount of power at this higher voltage, the line losses and voltage regulation would be even better than before, similar ratios to the above for a load of 800 kw. at .80 p.f. being 7.7 per cent. and 6.4 per cent. respectively. An automatic high-tension circuit breaker, with series transformers, controls the overloads at the power station. and at the sub-stations are h.t. circuit breakers, with series and shunt transformers, which cut out on overloads or voltage failures. For the protection of the line and apparatus against lightning, the stations have G.E. roller type arresters installed. These are of the low equivalent, non-arching, multigap type, with series and shunted gaps. The equivalent spark gaps are set to 1¼ inches, 2¼ inches, 3¼ inches, and 6¼ inches The performance of these arresters has been excel-

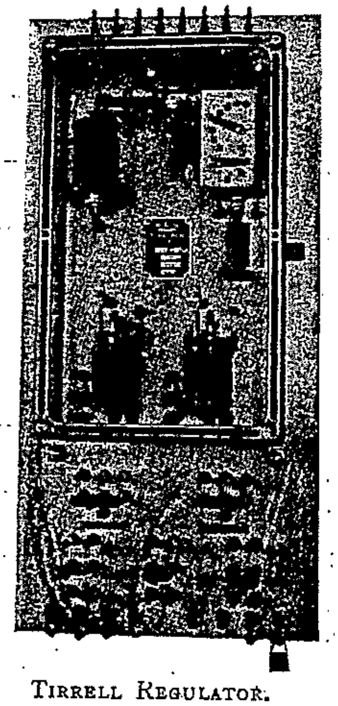
lent, considering that insulators have been shattered on the main line, and that over 50 thunderstorms occur in each year, some of which are very severe. As an auxiliary to the G.E. arresters, and to relieve them of their worst static stresses, the writer has installed supplementary horn arresters at the power station, with resistances to limit the current to full load line current. This has reduced the tendency of



3¼

the fuses in circuit with the G.E. arresters, to blow under severe conditions. The equivalent spark gap is, therefore, kept at its lowest and normal distance. Appended are actual sizes of some test papers punctured up to the 3¼ inch gaps. Note the calibre of the holes, which represent fair heavy currents. The first group of nine test papers show the effect of installing an auxiliary horn arrester on an outside wire (the right), to work in conjunction with the other arresters. After a very severe thunderstorm, in which a couple of line insulators were shattered, these papers, which were in the gaps of the G.E. arresters, were examined, and it can be seen that the stress on the same line as the auxiliary was least, little or no dynamic current following the static spark discharge. The test papers in the line adjacent were only punctured in the 1¼ and 2¼ inch gaps, whereas those in the other outside line showed punctures up to the 3¼ inch gap. Other tests have given similar results, displaying clearly the advantages of such a combination. The fact that the small gap in the horn arrester (which was set at ½ inch) allows it to act first, so



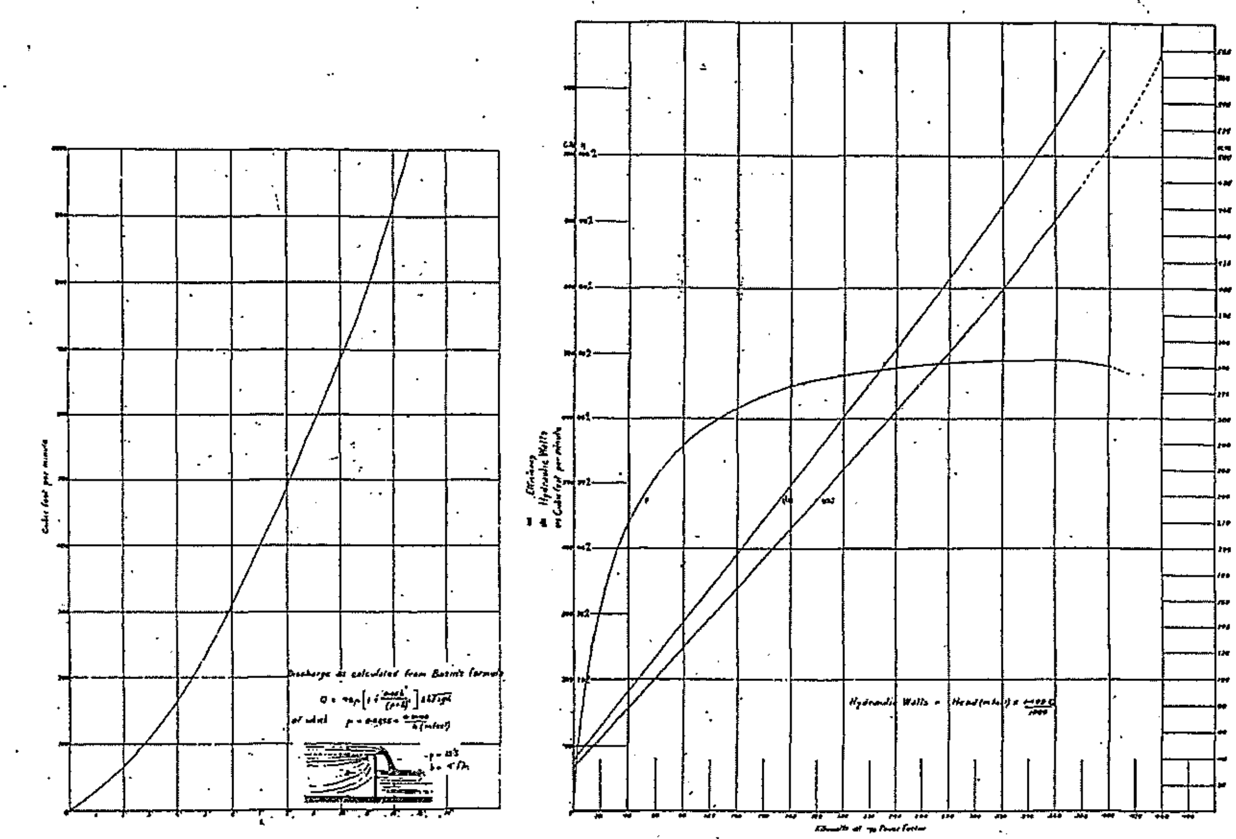
TIRRELL REGULATOR.

that damping results in the adjacent wire suggests to the writer that horn arrestors with small spark gaps, installed at regular intervals over the line on the middle wire, would have the effect of damping the surges in the two adjacent wires, and act in the same manner as an overhead earth conductor.* The writer was led to the investigation and practical application of the spark gap distance, and the spark lag with transient voltages from a perusal of some recent work on the subject by Dr. C. P. Steinmetz (Proc. Amer. Inst. E.E., Nov., 1910). The other

* This arrangement of arresters would only be applicable where the neutral of the system was not "earthed," as in the present instance

three test papers were obtained in the 3¼ inch gap before the horn arrestor was attached.

The telephone line is run approximately 13 feet from the main line poles, and, when in order, is comparatively quiet as far as the static and current induction from the main line is concerned. Two or three times during the operation of the plant, the telephone has served as an indicator of trouble in the main line by the excessive induction, due to unbalanced currents in the main line, which resulted on partial or complete shorting or earthing.



Efficiency Test Curves.

Rough tests of the performance and efficiency of the plant were made by the writer, and are given below.† These show that the performance is at least what might be expected, but must not be considered as rigorous, since certain refinements in the measurement of the water discharge and the calibration of wattmeters were not able to be made without the incurrence of considerable expense. The loading on the alternator was made with the actual working load, the instruments on the switchboard indicating, approximately, a power factor of .70 over the whole range, from 60 to 380 kw. The effect on the efficiency curve with unity p.f. would be to slightly peak this towards full load, and would probably increase the full load efficiency by 1 or 2 per cent. The combined efficiency of the turbine and generator would then be in the vicinity of 70 or 71 per cent. at full load. In measuring the water, the loss of head due to pipe friction was allowed for throughout the test. It amounted to 2.5 feet at full load, according to Weisbach's formula:—

$$h = \left(.0144 + \frac{.01716}{\sqrt{v}}\right) \frac{l}{d} \frac{v^2}{2g}$$

Where h = loss of head.
l = length of pipe in feet.
d = diameter of pipe in feet.
v = velocity of water in feet per second.

The cost per unit generated is .4d. depreciation, and interest, etc., being reckoned at 11 per cent., which allows a fairly high percentage for amortisation or obsolescence of the plant.

The whole plant has been in operation for nearly 2½ years, and has had an excellent record compared

† In conducting these tests the writer wishes to acknowledge the valuable assistance of Mr. T. H. Upton.

with other hydro-electric schemes in Australia. This reflects credit on the contracting engineers (the Allegemeine Electric Co., then represented by Messrs. Staerker and Fischer, and now by the Australian Metal Co.) and on the late manager, Mr. Frank J. Coote, who was in a way largely responsible for the general layout of the plant. It suffers, however, like some other schemes, from lack of water during the dry seasons. The advisability of obtaining exact information —extending over a few years, if possible—on the minimum flow of water in rivers from which is to be deduced the source of power for any hydro-electric scheme cannot be too strongly urged. Such information cannot be obtained from the inhabitants of the district, and little weight should be given conclusions not obtained by reliable and experienced engineers. To trust to a layman on this point is to court disaster, and projected schemes, bolstered up by such uncertainties, have been known to be a failure financially, when realised, through occasional shortness of water. Australia, although having many climes within itself, is not a country where many hydro-electric schemes of great magnitude could be made a financial success. Its sister countries, the Dominion of New Zealand and the State of Tasmania, are favoured of the gods in this respect. Droughts and floods have combined to form a wholesale dread of inaugurating water power, but wherever possible markets for the usage of electric current lie undeveloped through neglecting this source of power, we have a great national waste. Conservation of water in dams would generally be necessary, and the value of the "by-product," as we may term the "disenergised" water, for irrigation purposes cannot be overestimated. The excellent load factor accruing from irrigation concerns presents to the engineer an attractive feature in the development of hydro-electric schemes.

---

## ENGINEERING ASSOCIATION OF NEW SOUTH WALES.

The first meeting for the year was held on 9th March, when the president, Mr. G. A. Julius, B.Sc., delivered the presidential address. After referring to the progress and financial position of the Association, Mr. Julius introduced a question of great importance to the engineering profession—

*What is an Engineer?*

He said, inter alia:—There is no profession so prostituted as this of ours. Any fitter's labourer can, without other qualifications, set up his plate as an engineer, and can, and does, practice as such without let or hindrance. This is not so in the great sister professions of law and medicine, and it should not be tolerated in our science, which I am conceited enough to believe is of equal, or even greater, importance in the life of the community. We cannot at present stop any man calling himself an engineer, but, as a body, we can, and should, absolutely decline to accept him to membership of our Association until we have thoroughly satisfied ourselves as to his qualifications. Do not think for a moment I am presuming to suggest that this or that course of training is essential. There are many ways of becoming a qualified engineer, and numbers of our ablest men have started their careers as unskilled labourers.

*Engineering Progress.*

Passing on to refer to important developments during the past twelve months, Mr. Julius first mentioned the Humphrey internal combustion pump (description of which appears elsewhere in this number). The next question of importance was that of steam versus internal combustion engines as prime movers. With very small units, the latter undoubtedly leads; but above, say, 50 h.p., the question is still in doubt. Steam is certainly the more reliable medium, and a plant can be allowed to get into a deplorable condition before it refuses duty; whereas a gas engine must be maintained up to a certain standard. So far as efficiency is concerned, the results realised with high class gas plants are practically unattainable with steam, but some very remarkable results have nevertheless been recorded. For instance, the turbo alternator sets recently installed at the Ultimo tramway station (Sydney) have each a nominal capacity of 5000 k.w. at 6600 volts, but their overload capacity is phenomenally high, being 7500 k.w. The steam consumption realised on tests *in situ* was 16 lbs. per k.w. hour, using steam without superheat.

On the new 4000 k.w. sets now in hand for the Sydney City Council the guarantees call for a consumption of steam at 100 degrees superheat of not more than 15¾ lbs. per k.w. hour at full load, and 17½ lbs. at half load. Practically speaking, these figures correspond to a consumption of 1.1 lbs. of good Newcastle coal per b.h.p., or reduced to the British standard, 1.03 lbs. of best Welsh steam coal per b.h.p. hour, which again gives a figure of approximately 260 b.t.u. per b.h.p. minute, a result directly comparable with the data given for the Humphrey pump. It must, of course, be remembered that the 250 b.h.p. expended in the case of the latter appliance was expressed at per pump horse power minute, i.e., it is inclusive of both engine and pump losses, whereas in the steam plant the 260 b.t.u. includes losses only up to the turbine shaft.

With another class of steam plant, viz., semi-stationary combined engine and boiler, in which

Reprint of a paper presented at the Annual Conference of the Institution of Engineers, Australia in Adelaide, April 1980.

Reference: Engineering in the 80's, Adelaide 14-18 April 1980. Conference Papers, 7-12. Institution of Engineers, Australia, 1980.

# A PIONEER HYDRO - ELECTRIC SCHEME

JOHN McCUTCHAN, Senior Lecturer in Electrical Engineering
University of Melbourne.
RAY SUMNER, Historian, National Parks Service, Victoria.

SUMMARY In 1908 Victoria's first significant hydro-electric scheme was built to supply power to a gold mine 15 miles away. Using documents which have recently become available, this paper gives a detailed description of the design, construction, operation, and closure of this pioneer scheme.

## 1. INTRODUCTION

The Report on the Alpine Study Area published by the Land Conservation Council, Victoria, in July 1977 noted that the area around Cassilis (150 miles* East of Melbourne) contains features of recreational interest including early mining sites. Further investigations indicated the potential for Cassilis to be an important historic area where a major example of the legacy of gold-mining in the Gippsland mountains might be preserved (9**).

It was noted that current mineral leases were held over the Cassilis and King Cassilis mines, which had operated spasmodically until recently. Contact was made with lessee, Mr. John Avery, whose information gave the major impetus to the present research. Mr. Avery generously loaned us a set of photographs of mining at Cassilis from the 1890's to the 1960's, when he himself operated a mine there; more importantly, he also has an original copy of the 1907 tender document (1**) for what is thought to have been Victoria's first significant hydro-electric scheme, built by the Cassilis Gold Mining Company because of the shortage of firewood. Its purpose was to supply up to 400 kW by utilising a fall of about 400 ft* in the Victoria River in the last few miles before it joins the Cobungra River. The power was then transmitted 15 miles to Cassilis by what was by local standards a very innovative high voltage transmission line.

This copy of the tender document was used as a notebook by Mr. Avery's father (Mr. John Avery, 1873-1962) while he was employed by the Cassilis company throughout the construction of the hydro-electric scheme. These technical annotations (2) are particularly valuable as engineering records, as are a number of loose contemporary documents (3) relating to the scheme.

---

* To avoid pendantic conversions of historic data all numerical values are left in contemporary units.

** References are listed in Section 10.

## 2. MINING AT CASSILIS

The first gold at Swift's Creek was found in 1854 (4), and the area was worked intermittently in a series of rushes of varying importance for the next forty years. In 1858, William Power discovered the first quartz reef in Gippsland, near the junction of Power's Creek and Swift's Creek on the south side (5), see Figure 1.

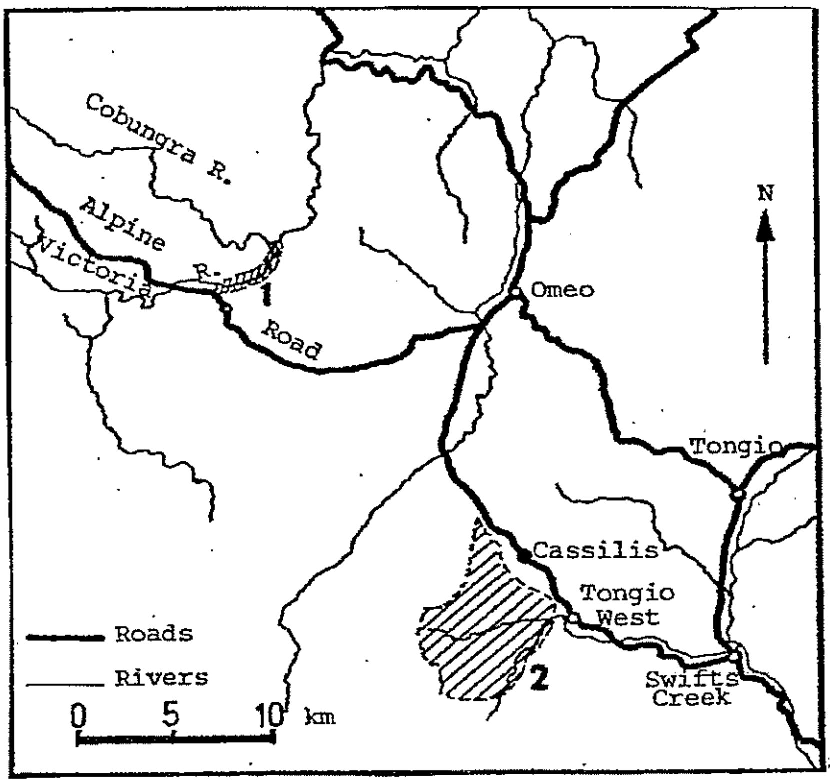



Figure 1. Locality Map

LEGEND:

1 Victoria River Falls
2 King Cassilis Mine

Proposed Historic Areas

Late in 1864, the first reef to be worked at Swift's Creek itself was opened and by 1866 there were applications for 21 quartz leases in the Swift's Creek watershed (6). The Swift's Creek Crushing Battery opened a 15-head battery late in 1867 but by March 1868 only one set of stamps could be used because of a water shortage, and by December of that year water was so scarce that all alluvial mining ceased. This was a presentiment of the later history of mining in the area. In 1873 the battery ceased operation and was removed.

The important phase of quartz mining in the Cassilis area began in 1885 when reefs were re-opened and worked. Almost 70 leases were granted by 1889. A ball mill was installed instead of a stamp battery, but this proved a failure.

## 3. THE CASSILIS COMPANY

In 1890, the reef which the Cassilis Company later worked was discovered by Robert Howard and worked by a local party until 1898 when it was purchased by the Cassilis Gold Mining Company, No Liability, formed on June 1, 1897, with a capital of £12,000 in 10/- shares held by 300 shareholders (21).

The Cassilis Company bought in January 1900 the entire plant of the Mount Hepburn Company Limited, which had operated the Mount Hepburn mine since 1893, including amongst the machinery an Otis Crusher Size No. 2 (1893), a 20-head stamp battery (1897), and a cyanide plant (1898). The battery was set up in Power's Gully, a gravity tramline was constructed from the mine to the plant, two furnaces and a chlorination works built and a Jacques rock-breaker installed. Continued improvements added a new compressor, more furnaces, a foundry, a dynamo for electric lighting, an amalgamating barrel and a cyanide plant (6).

The Cassilis Company soon became the premier mine in the district, employing at its peak about 200 men. However it suffered from two problems common to all quartz mines in that period,

- A decrease in the thickness and quality of the quartz reefs as they were followed down (see Table 1).
- A corresponding increase in the energy needed to extract and crush sufficient quartz to meet costs.

| | Ore Crushed | Gold Yield |
|---|---|---|
| | Tons | Ounces |
| 1898 | 240 | 754 |
| 1899 | 1259 | 2364 |
| 1900 | 1355 | 2057 |
| 1901 | 3111 | 2975 |
| 1902 | 11420 | 8926 |
| 1903 | 6728 | 7203 |
| 1904 | 9353 | 9574 |
| 1905 | 13453 | 12024 |
| 1906 | 14187 | 12642 |
| 1907 | 8864 | 8483 |
| 1908 | 3708 | 2918 |
| 1909 | 16720 | 11593 |
| 1910 | 4955 | 3373 |
| 1911 | 9987 | 5217 |
| 1912 | 3164 | 1032 |
| 1913 | 4312 | 1528 |
| 1914 | 853 | 478 |
| 1915 | 317 | 244 |
| Total | 113986 | 93385 |

Table 1 - Output of the Cassilis Company

Source References (11) and (6).

Fuel supply was a constant problem to the mines of the Cassilis area. Boilers were originally fired with boxwood and, as supplies in the immediate vicinity were depleted, cutters were forced into higher country and inferior timbers. While huge quantities of wood were consumed, work still slowed down. By 1903 the Cassilis Company was using some 100 cords in a 6-day week (1 cord = 128 cubic feet), at a cost of £100 per week. Furthermore, estimated timber reserves were only two years, and quality was deteriorating while transport costs increased.

Faced with the need to reduce the cost per ton of quartz crushed, a bold scheme was conceived to replace the boilers and steam engines with electric motors, powered with electricity produced by a hydro-electric plant 15 miles away. The originator and designer of this scheme was probably the then mine manager, Francis James Coote, born in Dunedin (N.Z.) 1866, surveyor, draughtsman and expert in cyanide processing (7). Three other people were involved, John Avery, born 1873 near Ballarat, pharmacist, engineer, mining expert (8), who acted as manager while Coote was away on leave (23); Harold J. Wright, an erection engineer specialising on the electrical side (10); and Charles Moncrieff Sievwright, a construction engineer (6).

4. CONSTRUCTION OF THE HYDRO-ELECTRIC SCHEME

The scheme was approved in principle by the shareholders in August 1905, but financial considerations delayed approval to start for another 12 months (22).

In March 1907 a detailed specification and Conditions (1) were issued for the supply and installation of the turbines and electrical plant, and also the supply of wire and insulators for the high voltage transmission line and the telephone line. Seven Tenders were received from around the world, as follows (2):-

| | £ |
|---|---|
| Australian General Electric Co. | 8,418 |
| Allgemeine Electric Co., Berlin (A.E.G.) (Messrs. Staerker & Fischer) | 8,791 |
| British Westinghouse Co. (Noyes Bros.) | 9,558 |
| Scott & Mountain (McMicking & Co.) | 12,600 |
| Siemens Bros. & Co. | 12,550 |
| Gibson Battle & Co. (Mather & Platt) | 12,761 |
| Ganz & Co. (Alfred Adams) | 10,901 |

The second of these was accepted, and after some changes the costs of the main items were approximately as listed below (2):-

| | £ |
|---|---|
| 1 - 670 h.p. water turbine with governor | 660 |
| 1 - 500 kVA 3-phase alternator and exciter | 767 |
| 1 - 17 h.p. water turbine & d.c. generator | 155 |
| 18 - 1-phase transformers (4 @ 150 kVA, 4 @ 125 kVA, 4 @ 35 kVA, 6 @ 3 kVA) | 1,597 |
| Switchboards, instruments and wiring | 1,617 |
| 50 miles - 4.52 mm dia. copper wire | 1,582 |
| 1600 - insulators for H.V. line | 365 |
| 3 telephones, insulators, 32 miles wire | 86 |
| 18-wound rotor induction motors with control gear (1 @ 100 h.p., 2 @ 75 h.p., 10 @ 15 h.p.) | 1,665 |
| Services of 2 electricians | 475 |
| | £ 8,969 |

All materials were delivered to Bairnsdale railway station, from where they were taken by bullock wagons over rough tracks for 80 miles to the mine, 110 miles to the power station (1). Considering this and the climatic extremes, the speed of construction is amazing. From the issue of the Specification to the first commercial use took less than 18 months.

<u>1907</u>

| | |
|---|---|
| 6th March | Date on Tender documents and Specification (1). |
| 10th June | Closing date for Tenders for plant (1). |
| 26th June | "8 men (2 horses) cleared 90 chains transmission line per week" (2). |
| 6th July | Specification for Pipeline issued (3). |
| 21st November | Mephan Ferguson quotation for pipeline (2). |

<u>1908</u>

| | |
|---|---|
| 14th January | Date on Voith drawing of power station layout (3). |
| 20th March | Date quoted for delivery of pipes to Melbourne (2). |
| 26th August | "Current switched on line" (2). |
| 30th August | "Mine and mill started" (2,48,58). |

5. DESCRIPTION OF THE SCHEME (References 1,2,3*,12,13,22,34,46)

A low earth weir across the Victoria River diverted water through a regulating gate into a race line 3.6 miles long. This had a gradient of 10 feet per mile, and was cut into the sloping hillside on the left of the river. The race was an unlined trapezoidal channel 2'9" deep, 4'6" wide at the bottom and 6'8" wide at the top. It was predicted that the water would be 30" deep when the power station was supplying its ultimate design output of 800 kW.

The race ended in a small pondage, for which two quite different sets of dimensions are quoted - 145' x 45' x 10', and 1½ ch. x 1 ch. x 9ft. Even if the pondage was a rectangular tank, either of these produces only about half the quoted capacity of 750,000 gallons, indicating a rather uncritical transcription of data. (The present remains are oval in shape, with dimensions similar to the first set).

At one end of the pondage a rectangular concrete inlet structure housed the screens, leading to a 48" to 34" diameter transition pipe concreted in. This joined to the steel pipeline, comprising

635' of 34" dia. x 1/8" thick,
524' of 31" dia. x 3/16" thick,
376' of 28" dia. x 1/4" thick,

* Of the various descriptions of the plant found so far, by far the most detailed on the electrical aspects is a copy of a rought draft of a paper, among the loose documents in Mr. Avery's possession. This is headed "Hydro Electric Plant for the Cassilis Gold Mining Company, Victoria" by H.J. Wright, and comprises 21 foolscap pages, typed double spaced, with extensive corrections written in. The paper refers individually to 55 photographs showing many details, and appears to have been written early in 1910. If these photographs are ever found the authors would be very interested to see them.

a total of 1535 feet with a vertical fall of 413 feet. The pipes were double rivetted longitudinally, with flanged joints, and were supplied by Mephan Ferguson Foundry of Footscray, Victoria, for a total of £1557. At the works the pipes were tested at twice working pressure, and were then dipped in a bath of tar and asphaltum. The pipeline was buried in a shallow trench, except at the joints, and ran in a straight line down to the power station located on level ground beside the Cobungra River, about ½ mile above its junction with the much smaller Victoria River.

The power station is shown in Figures 2 and 3 (13 and also Mr. John Avery).

The main turbine was a Voith Pelton wheel, rated at 670 h.p. max. at 390 ft nett head when running at 500 r.p.m. The maker quoted a water consumption of 540 litres/sec. giving an efficiency of 79%. An oil governor was used to move tongues in two rectangular nozzles; and a relief valve was provided to limit transient pressure rises. The large cast iron fly wheel visible in Figure 3 was 8 ft in diameter and 6" wide at the rim, and weighed about 6000 lb.

This turbine was connected through a flexible coupling to an A.E.G. 3-phase alternator rated 500 kVA, 500 volt, 50 Hz., having an overload capability of 25% for 2 hours. Its stated efficiency at unity power factor was 93% at full load, and 89% at half load. On the end of the shaft was a 6.3 kW, 115 volt exciter.

A second Voith Pelton wheel rated at 17 h.p. drove a 10 kW, 115 volt d.c. generator, capable of supplying station lighting and acting as a spare exciter. Provision was made in dimensioning the race and pipeline for adding a duplicate main turbine and alternator, to give a total maximum electrical power output of about 900 kW. From the beginning Mr. Coote has appreciated the possibility of selling excess power to other mines in the district, and to Omeo township 12 miles from Cassilis.

The output of the alternator was connected directly to three single-phase oil filled A.E.G. transformers each rated 150 kVA, 290V to 12 kV, with another as a spare. The low voltage windings were connected in star and the high-voltage windings in delta. It was intended that the latter would be reconnected in star when the station capacity was doubled, at which stage a second set of transformers would be needed.

The high voltage output was fed through a 20 kV, 50 amp oil circuit breaker to three outgoing line cubicles containing coke coils and G.E. multigap lightning arrestors. Current and voltage transformers operated the usual range of instruments and also a Tirrell regulator controlling the alternator field current in response to changes in the high voltage output.

The transmission line consisted of three solid hard-drawn copper conductors, 4.5mm in diameter. The 15.6 mile route reached a maximum altitude of 4800 feet, much of it being subject to severe gales, thunderstorms, and snow. A track 66 feet wide was cleared through the mountainous and mostly timbered country, some 490 wood poles and about 60 trees being used to support the wires at intervals of about 50 yards. Porcelain insulators tested to 80 kV dry, 45 kV wet were used, one on top of the pole and two on a cross arm to space the wires 5 feet apart in an equilateral triangle.

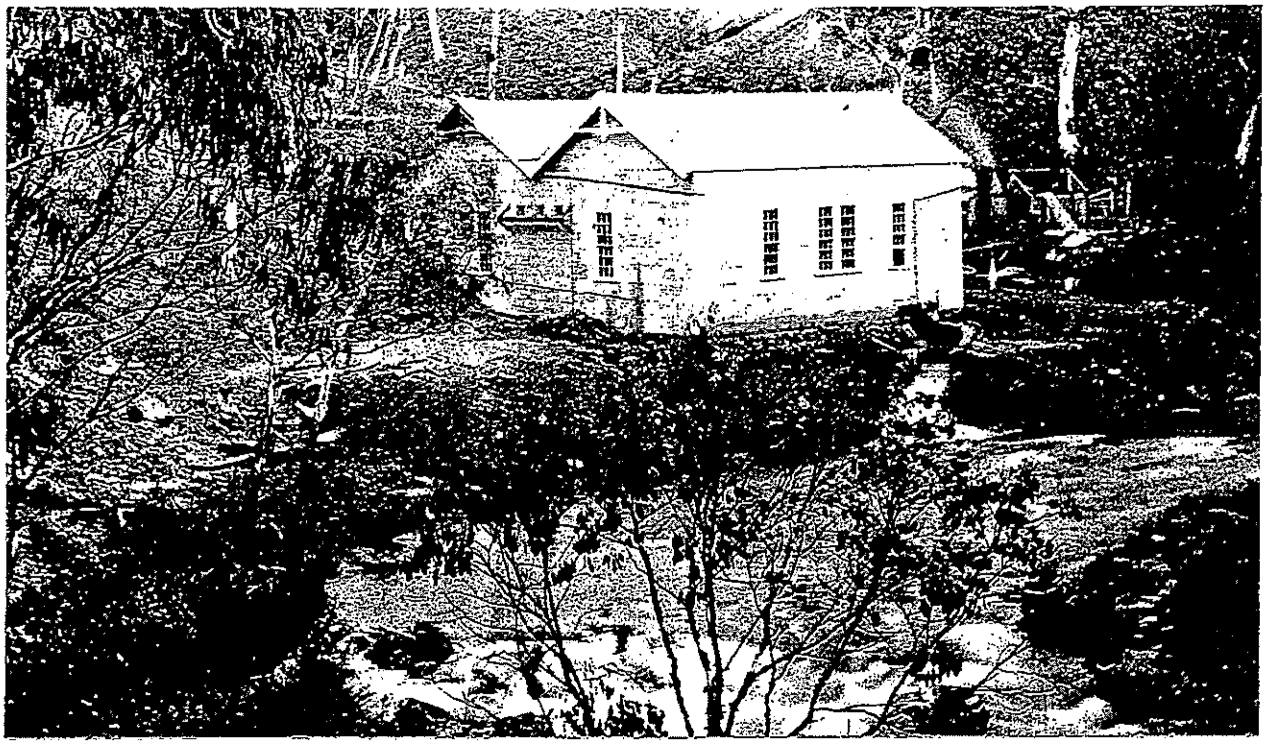


Figure 2 - Power House on Cobungra River

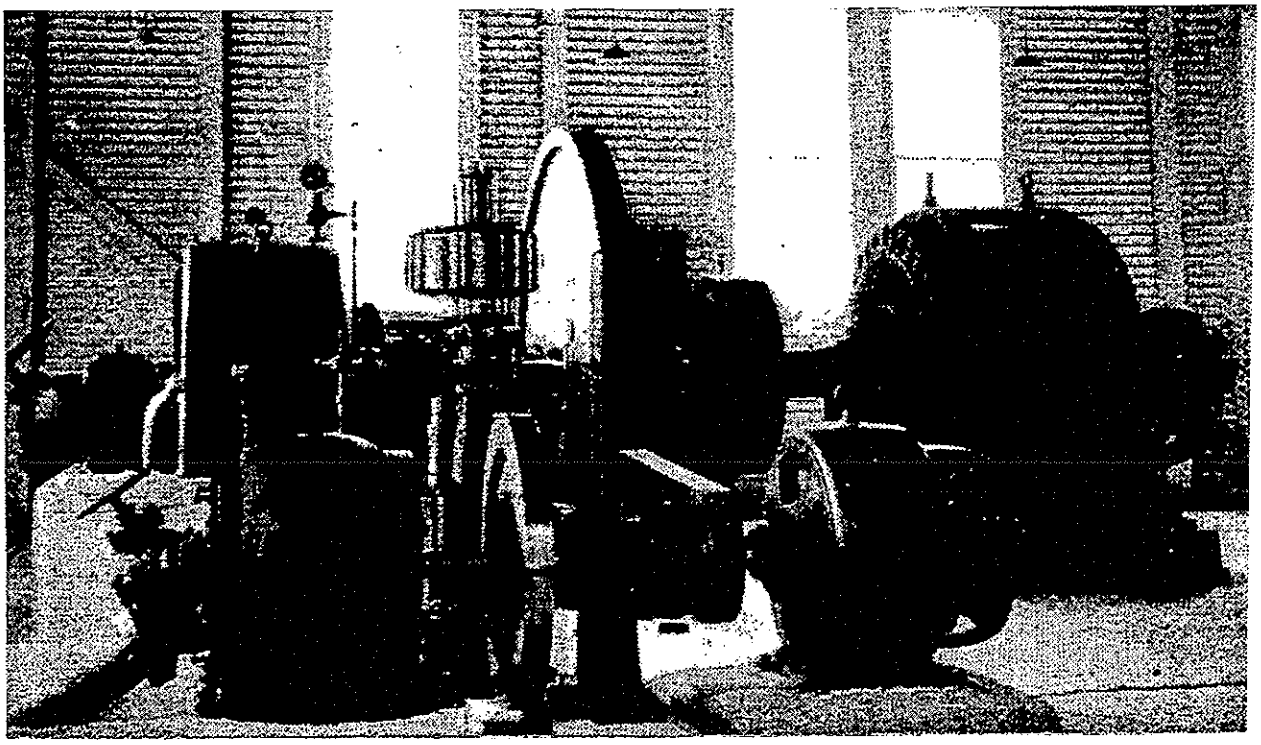


Figure 3 - Interior of Power House

In the background is the main set L. to R. 670 h.p. turbine/flywheel/500 kVA alternator.

A 2-wire telephone circuit was run on trees along the edge of the transmission line clearing. This could be tapped at any point by means of light staff contacts, enabling a patrol man to communicate with either end of the line.

The transmission line ended at a sub-station near the Treatment Works, where most of the electrical load was located, and had a short branch to another sub-station near the mine. At each sub-station the lines went to lightning arrestors and choke coils similar to those at the power station, and then through an oil circuit breaker to the step-down transformers. These comprised three single phase units connected delta-star, each having voltage ratio 10.75 kV to 332V, and rated at 125 kVA and 35 kVA for the Works and Mine respectively. A fourth transformer was kept as a spare for each 3-phase bank.

The low-voltage output fed the 550 volt 3-phase motors, and a number of 3 kVA single phase 575/115 volt transformers for lighting circuits. At the Works there were two small squirrel cage motors, and 9 wound rotor motors ranging from 15 to 100 h.p. all with liquid starters. (Subsequently a 320 h.p. wound rotor motor was added, direct coupled to a new Bellis Morcomb air compressor, with a liquid starter).

Air pollution at the Treatment Works must have been very severe, judging by the following extracts from the Tender Information and Specification (1). p.4: "For the last third of a mile into the Works Receiving Station the Lines will be subjected to heavy sulphurous fumes from the stack of the roasting furnaces, and occasional chlorine fumes from the chlorination plant."
p.15: "Insulated Conductors: It will be necessary to protect these, either by very thick insulation, or some preparation which will be durable and reasonably permanent, and can be renewed. The copper telephone wires originally erected in connection with the works were eaten through at the insulators two months after erection, and heavy iron wire was substituted."

Surviving documents merely state that "within one third of a mile of the works the main line is run with special acid proof wire," but more details are given for the low-voltage distribution. "The whole of the cable used around the works is of the A.E.G. special acid proof type consisting of three layers of braided jute impregnated with white lead without further insulation.

From the Mine Sub-station, 550 volt 3-phase overhead lines ran 400 ft and 700 ft to two 75 h.p. wound rotor motors driving winches for the Cassilis and Ceresa shafts. These double-drum winches were made in the mine foundry and workshop, and could raise one ton at 800 feet/minute from 1000 feet down. This on-site capability was very necessary for mines in remote parts of Victoria, to avoid freight costs on heavy renewable components such as stamper shoes, and to reduce the time taken for repairs after any breakdown.

The electrical plant was erected and commissioned in less than 3 months by two of the Contractor's engineers, with unskilled labour provided by the Company. The methods used to dry out the transformers are an interesting contrast to modern practice. For each 3-phase bank the 3 cores and windings were removed from their tanks and heated for about 80 hours by passing about 3/4 rated current through the windings. The transformer oil was dried separately in large iron tanks over a wood fire. After about 24 hours at 220°F the oil was run into the transformer tanks, and the hot cores were lowered in later.

## 6. OPERATION OF THE SCHEME

Within 5 months of starting up, a shortage of water reduced the power available to the mine, as shown by the energy figures in Table 2 (2,51). The report for the half year ending 8/2/09 stated that "the full benefit of the power system has, however, not yet been felt, owing to an exceptionally dry season, but with the completion of a large storage dam at the head of the Victoria River race, the company will be unaffected by future droughts" (27,49).

| 4 weeks ending | MWh Gen. @ Cobungra | Hours run | Average kW | MWh used @ Mine/Works |
|---|---|---|---|---|
| 1908 | | | | |
| Sept 25 | 20.5 | 471 | 44 | - |
| Oct 23 | 74.7 | 613 | 122 | - |
| Nov 20 | 68.8 | 600 | 115 | 60.5 |
| Dec 18 | 80.7 | 594 | 136* | 71.9 |
| 1909 | | | | |
| Jan 15 | 35.3 | 528 | 67 | 32.2 |
| Feb 12 | 30.3 | 578 | 52* | 28.6 |
| Mar 12 | 40.1 | 620 | 65 | 35.9 |
| Apr 9 | 30.5 | 588 | 52 | 27.6 |
| May 7 | 29.1 | 629 | 46* | 26.5 |
| June 4 | 81.1 | 647 | 125 | 72.4 |
| July 2 | 100.5 | 599 | 168 | 89.5 |
| July 30 | 114.4 | 607 | 188 | 98.2 |
| Aug 27 | 113.2 | 606 | 187* | 96.5 |
| Sept 24 | 110.4 | 588 | 188* | 95.1 |
| Oct 22 | 102.6 | 572 | 179* | 89.4 |
| Nov 19 | 98.1 | 576 | 170 | 85.8 |
| Dec 18 | 95.8 | 606 | 158* | 85.1 |
| 1910 | | | | |
| Jan 14 | 38.3 | 531 | 72 | 34.7 |

Table 2 Energy Production and Use in First 16 Months

* These values have been changed slightly from the original tabulated kW values, on the assumption that the kWh and hour figures are correct, and the manual division was in error.

Confidence was high, and in April 1909 an order was placed for a large Belliss air compressor and a 320 h.p. A.E.G. motor. This was needed because the old smaller air compressor (driven by a new 100 h.p. motor) "proved unequal to the work" (3,28,50).

The August 1909 report stated that "the large saving anticipated, as the result of the operation of the hydro-electric scheme, has not yet been realised.

"Though the effect of the new system was noticeable in the results obtained in the early part of the year, difficulties have been experienced which have made the term ... somewhat disappointing. Water scarcity was one of the troubles, but the directors consider it unnecessary to continue the construction of the storage dam, in view of the rainfall, this trouble should not recur" (29).

Hard reality was faced during the summer of 1909-10, when owing to shortage of water one shift per day was suspended "for the present" (30). In the February 1910 report it was noted that the £22,000 spent on the scheme was double the preliminary estimate, and exceeded Mr. Coote's forecast of £17,000 for his enlarged version of the scheme. Reasons given included an unexpected tariff, a rise in the price of copper, and a 40% rise in transport costs "owing to the high cost of feed". The "exceptionally dry season" was also blamed (31,47). Whatever the cause, the company was left with very little money to spend on the mine or a storage dam. Fairweather reports that "Mr. Frank Coote was farewelled on 5/4/1910" (6).

The situation deteriorated during the next few years with frequent changes of manager, each with different views on how the highly mineralised ores should be treated (6,33,52,53,54,56). After a thorough investigation, one expert reported "that a complete lack of metallurgical knowledge was evident on the part of the management in both the cyanide and metallurgical processes". He was forthwith invited to become the new manager, and accepted (57).

From time to time the mine was restricted or closed completely due to lack of water power, and the various managers agreed in considering a £3,000 water race to the Cobungra River "essential to ensure continuous working" (32,35,55). However, even in March 1911, after 3 summers, "the directors think the rainfall will suffice to keep the hydro-electric plant running" (32).

From 1913 to 1915 the company struggled on, with the usual power shortages aggravated by decreasing tonnages of payable ore (36 to 40). It could not even proceed with a scheme for the development of the mine, towards which the Mines Department had allotted £4,000 (59).

A small earth storage dam was finally built at the end of 1915, but in June 1916 "the newly constructed dam washed out, mainly because of its hurried construction, with the walls not being properly consolidated" (6,24,25,60). Three months later the mine closed, and in October 1916 the entire company was sold for £4,735 (26,41,61). The new owners decided to auction the assets, the hydro-electric plant being purchased by the Magnet Silver Mining Company of Waratah, Tasmania, who had been considering installing such a plant for some time (42,43). The plan was subsequently dismantled and re-erected at Waratah in 1918 (44,45).

## 7. THE PRESENT REMAINS

Many interesting relics remain at the former Cassilis site, the most spectacular being over 20,000 tons of coloured battery sand which chokes Power's Gully. Huge grey mullock heaps above the valley mark former mine entrances. The site of the Cassilis battery as shown on old photographs, is clearly discernible and a few bricks, stones and stumps mark other sites of buildings and plant and part of a Tramway. The concrete cubicles which enclosed the high voltage lightning arrestors still mark the site of the sub-stations at the ends of the transmission line.

At the Victoria River area the remains of the short-lived earth dam and the start of the water race are clearly visible from the road, just after it crosses the river. From then on the road marked "Victoria Falls" was built on the line of the old water race in 1965 (12), and ends abruptly in a loop around the small pondage.

At the North end of this pondage the rectangular concrete inlet structure remains intact, as does the first tapering section of the pipeline, which was concreted in place. All the flange jointed pipes have been removed, possibly in 1917 with the rest of the plant, but the straight pipe trench is visible in many places. A rough track winds down to the Cobungra River, beside which the concrete floor of the power station remains in good condition. Still intact are the foundation blocks of the turbines, governors, and generators, complete with the bolts which held the machines in place. Three concrete cubicles mark the start of the high voltage transmission line.

The subsequent history of the hydro-electric plant has not yet been followed up, but it is quite possible that it still exists in Tasmania. The authors would be very interested to hear of Voith or A.E.G. plant matching the ratings given*.

---

* Marginal notes (2) give works numbers 2814, 1240, 157473, and 157869 (Voith); 336579, 357198, 357199 (AEG generators); 17287, 18659 (AEG transformers)

In their Final Recommendations - Alpine Area, the Land Conservation Council, Victoria (20) propose the setting aside of various historic areas. These include 100 ha at Victoria Falls, (encompassing the dam, race, pondage, and power station site), and 3620 ha at Cassilis. In the Recommendations these two areas would be managed by the National Parks Service, and would be used to:

(a) provide opportunities for recreation and education associated with the enjoyment and understanding of their history;

(b) protect the sites and the remnants of buildings, equipment, construction works, and artifacts associated with the history of the locality.

## 8 POST MORTEM CONCLUSIONS

The significance of this scheme completed in 1908 can be appreciated in relation to some other hydro-electric schemes:

1881 Godalming, Surrey - 4 arc lamps and several Swan lamps.
"The first in the world for public lighting" (14)

1887 Reefton, New Zealand - dc plant for mine & town.
"The first public supply in Australasia" (15)

1895 Thargomindah, Queensland - 12 kW, 220V dc (15)
Launceston, Tasmania - 300 kW, 1-phase 92 Hz, plus dc (16)
"The first in Australia"

In Victoria, the 400 kW output of the Cassilis plant was not exceeded until -

1928 Rubicon/Royston group. Rubicon Falls (300 kW) 1926; others totalling 12 MW 1928 (17).

As described already, the scheme failed through lack of available water, and it is easy to blame this for the closure of the mine (6). Certainly the lack of power curtailed mining operations for long periods, at times when large outputs of ore were needed to compensate for the poorer grades. On the other hand, if the scheme had not been built, would the company have been able to afford (or even obtain) sufficient firewood? This was a period when gold mines were closing down all over Victoria, and we will not attempt a conjectural economic analysis of the "If only" type.

Two aspects, however, are amenable to engineering analysis. The first is the repeated claims that each year in turn was "exceptionally dry". River gaugings were taken on the Cobungra River about ½ mile downstream from the Victoria River junction from 1925 to 1935 (18). These have been plotted in Figure 4, together with corresponding figures for the Mitta Mitta River (into which the Cobungra flows) at two places further downstream. The similarity of the 3 graphs over these 9 years suggests that the flow of the Victoria River from 1908 to 1916 (for which records are not available) might be inferred from the long term records for the Mitta Mitta, Figure 5.

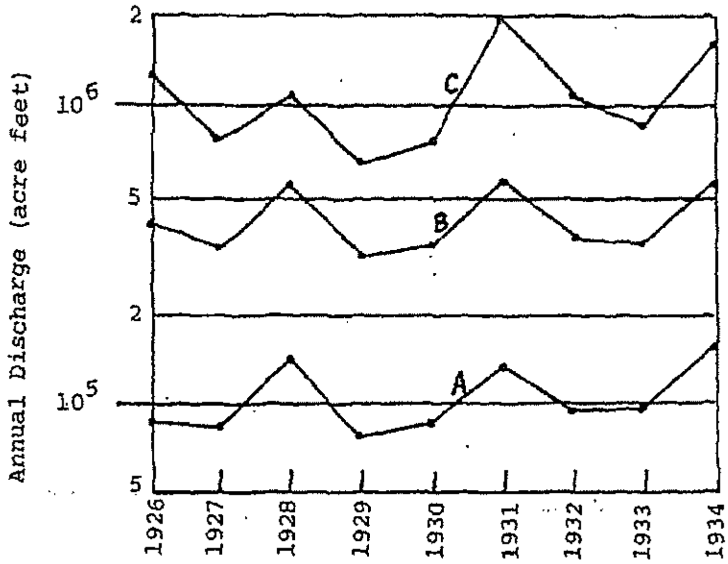



Figure 4 - Annual River Discharges

A Cobungra R., ½ mile below Victoria R.
B Mitta Mitta R., at Hinnomunjie.
C Mitta Mitta R., at Tallangatta.

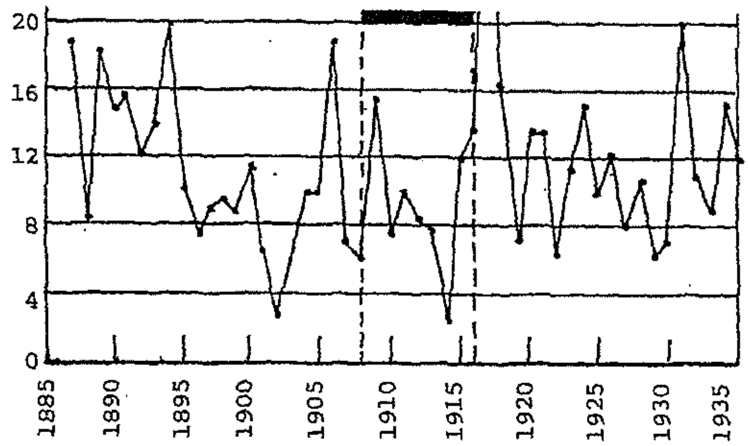



Figure 5 - Annual Discharges

Mitta Mitta R. at Tallangatta. ($10^5$ acre feet).

This shows that for the Mitta Mitta as a whole, the only year between 1908 and 1916 which could be considered "exceptionally dry" was 1914.

The second point concerns the proposed storage dam on the Victoria River (2,22,29 etc). Space precludes a full analysis, but our calculations show that even the largest version proposed would not match the normal annual rainfall variations (19).

## 9. ACKNOWLEDGEMENTS

This paper could not have been written without the considerable assistance of Mr. J. D. Avery, Melbourne. We also acknowledge the assistance of Mr. C. Ashe (Land Conservation Council) and Mr. R. King (Department of Minerals and Energy).

## 10. REFERENCES

(1) Tender document "Hydro-Electric Power Plant for the Cassilis Gold Mining Company, No Liability", March 6th, 1907.

(2) Annotations by John Avery (snr.) on (1).

(3) Loose contemporary documents in possession of John Avery (jnr.)

(4) FLETT, J. The History of Gold Discovery in Victoria, The Hawthorn Press, Melbourne, 1970.

(5) Reports of the Mining Registrars, Mines Department of Victoria, September, 1886.

(6) FAIRWEATHER, K.McD. Time to Remember. The History of Gold Mining on the Tambo and Its Tributaries, Yeates, Bairnsdale, 1975.

(7) SMITH, J. (ed). The Cyclopedia of Victoria Vol. II p 273, The Cyclopedia Company, Melbourne, 1903.

(8) EAST, L.R. The Kiel Family and related Scottish Pioneers, Vol. II of A Family Who's Who 1974.

(9) AXEDALE MINING CO. PTY. LTD. A Preliminary study of the Charlotte Spur Track, the Jirnkee Water Race, The Mount Hepburn Treatment Works, and Oriental Claims. Shire of Omeo. National Estate Program 1977/1978. 1978.

(10) WRIGHT, E.H. The Early Days of Hydro-Electric Power. Victorian Historial Magazine Vol. 35 (3), August 1964, pp 116-119.

(11) The Goldfields of Victoria - Monthly (later Quarterly) Returns. Mines Department Victoria, 1899 to 1914.

(12) PEARSON, A.M. Echoes from the Mountains, Yeates, Bairnsdale 1969.

(13) ALLISON, A. The Cassilis Hydro-Electric Plant. The Mining and Engineering Review Vol. 3, 5th April 1911, pp 291-297 (Also listed as Reference 34).

(14) TUCKER, D.G. Hydroelectricity for public supply in Britain, 1881-1894, Proc. I.E.E., 123, 1976, pp 1026-1034.

(15) Tait's Electrical Directory of Australia and New Zealand, 11th Ed. 1939. Tait Publishing Co., Melbourne.

(16) MURRAY, K.L. Electric Lighting of Launceston, Tasmania, Papers of the Victorian Institute of Engineers, Vol. 2, Melbourne 1897

(17) STATE ELECTRICITY COMMISSION OF VICTORIA - 9th Annual Report 1927-28.

(18) STATE RIVERS AND WATER SUPPLY COMMISSION, Victorian River Gaugings to 1965, Gov't. Printer, Melbourne.

(19) AUSTRALIAN BUREAU OF METEOROLOGY - Rainfall Statistics, Victoria, 1931-1960

(20) LAND CONSERVATION COUNCIL, VICTORIA, Final Recommendations - Alpine Area, Melbourne, June 1979.

Omeo Standard

| | | | |
|---|---|---|---|
| (21) | 14/1/98 | (22) | 27/9/07 |
| (23) | 18/10/07 | (24) | 9/6/16 |
| (25) | 25/8/16 | (26) | 1/9/16 |

(Australian) Mining and Engineering Review (Title varies)

| | Vol. | Date | Page | | Vol. | Date | Page |
|---|---|---|---|---|---|---|---|
| (27) | 1 | 5/3/09 | 185 | (28) | 1 | 5/5/09 | 244 |
| (29) | 1 | 6/9/09 | 394 | (30) | 2 | 5/1/10 | 136 |
| (31) | 2 | 5/3/10 | 200 | (32) | 3 | 6/3/11 | 256 |
| (33) | 3 | 5/4/11 | 282 | (34) | 3 | 5/4/11 | 291-7 |
| (35) | 4 | 5/3/12 | 252 | (36) | 5 | 5/3/13 | 241 |
| (37) | 5 | 5/9/13 | 490 | (38) | 6 | 5/11/13 | 62 |
| (39) | 6 | 5/9/14 | 362 | (40) | 7 | 6/9/15 | 294 |
| (41) | 9 | 6/11/16 | 48 | (42) | 9 | 5/12/16 | 71 |
| (43) | 9 | 5/3/17 | 157 | (44) | 9 | 5/7/17 | 271 |
| (45) | 10 | 5/12/17 | 89 | | | | |

Australian Mining Standard

| | Vol. | Date | Page | | Vol. | Date | Page |
|---|---|---|---|---|---|---|---|
| (46) | 38 | 20/11/07 | 485 | (47) | 40 | 26/8/08 | 240 |
| (48) | 40 | 9/9/08 | 284 | (49) | 41 | 10/3/09 | 252 |
| (50) | 42 | 1/9/09 | 230 | (51) | 42 | 1/9/09 | 238 |
| (52) | 43 | 16/3/10 | 263 | (53) | 44 | 7/9/10 | 264 |
| (54) | 44 | 12/10/10 | 380 | (55) | 45 | 8/3/11 | 245 |
| (56) | 45 | 29/3/11 | 310 | (57) | 45 | 18/5/11 | 485 |

Mines Department (Victoria) - Annual Reports

| | | | |
|---|---|---|---|
| (58) | 1908, p 128 | (59) | 1914, p 101 |
| (60) | 1915, p 50 | (61) | 1916, p 20 |

# Cassilis Hydro-electric Scheme

Images and Captions
relating to
Page 8
of
Nomination

Cassilis Hydro-electric Scheme – Image 1

A Bullock Team transporting plant 160 km from Bairnsdale Railway Station to the Cobungra River

## Cassilis Hydro-electric Scheme – Image 2

The 24 km transmission line route crossing the Great Dividing Range

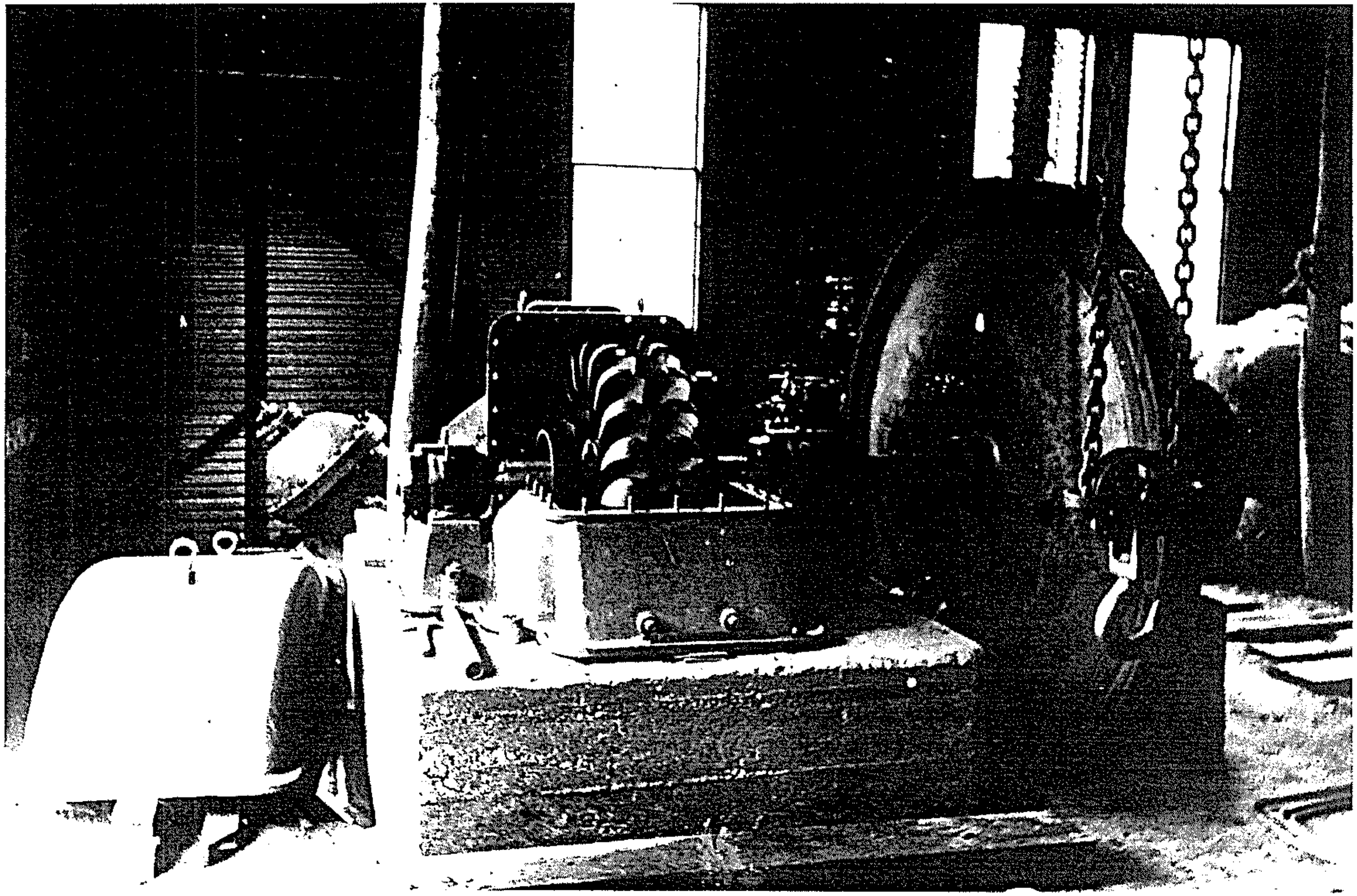
Cassilis Hydro-electric Scheme – Image 3

The 5 km water race

Cassilis Hydro-electric Scheme – Image 4

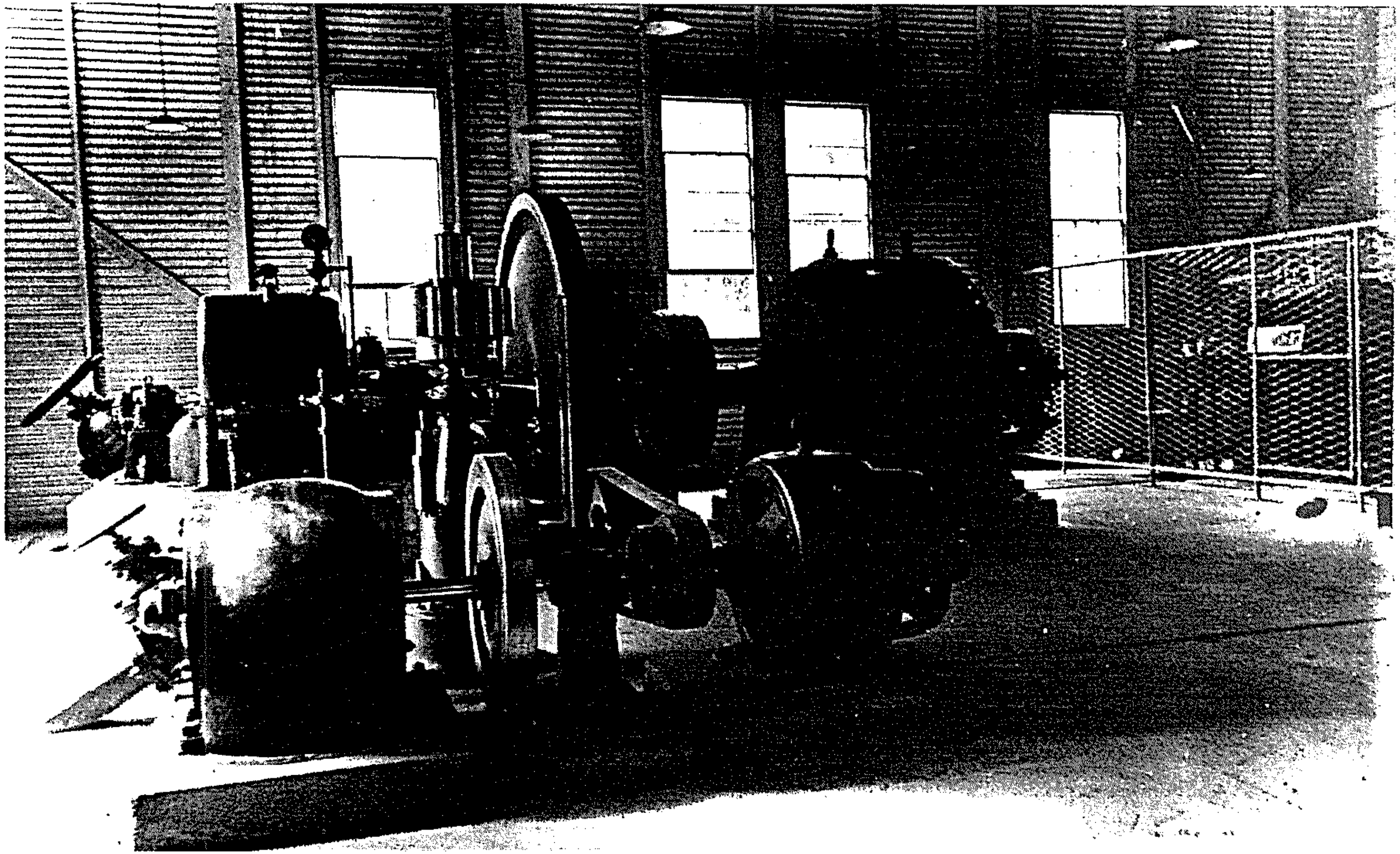
Lowering the riveted steel pipeline from the forebay

Cassilis Hydro-electric Scheme – Image 5



The 670 HP Turbine and Flywheel during erection

Cassilis Hydro-electric Scheme – Image 6

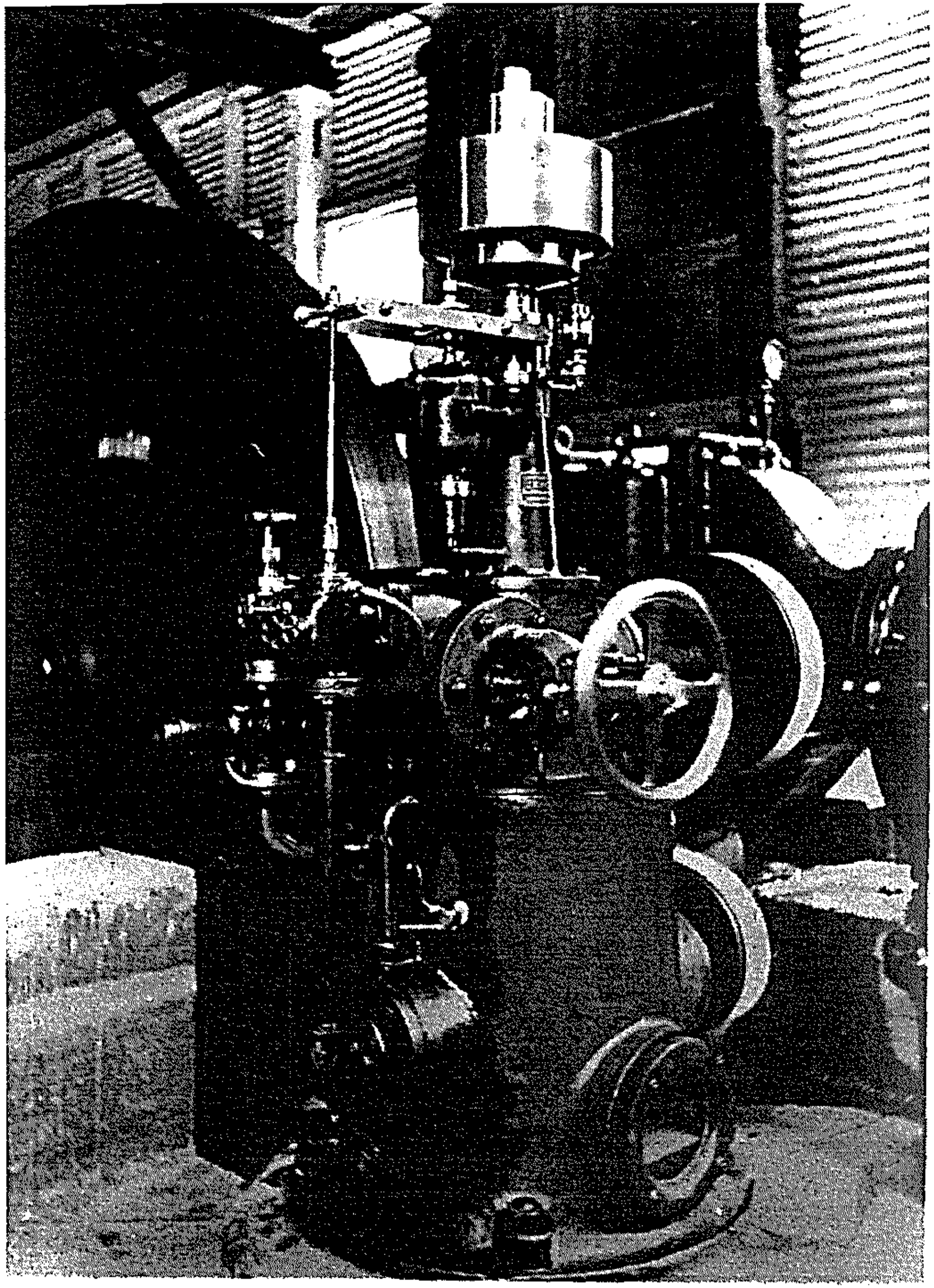


The completed plant : 670 HP Turbine/500 kVA Alternator at the rear, 17 HP turbine/10 kW auxiliary generator at front, HV step-up transformers at far right.

Cassilis Hydro-electric Scheme – Image 7

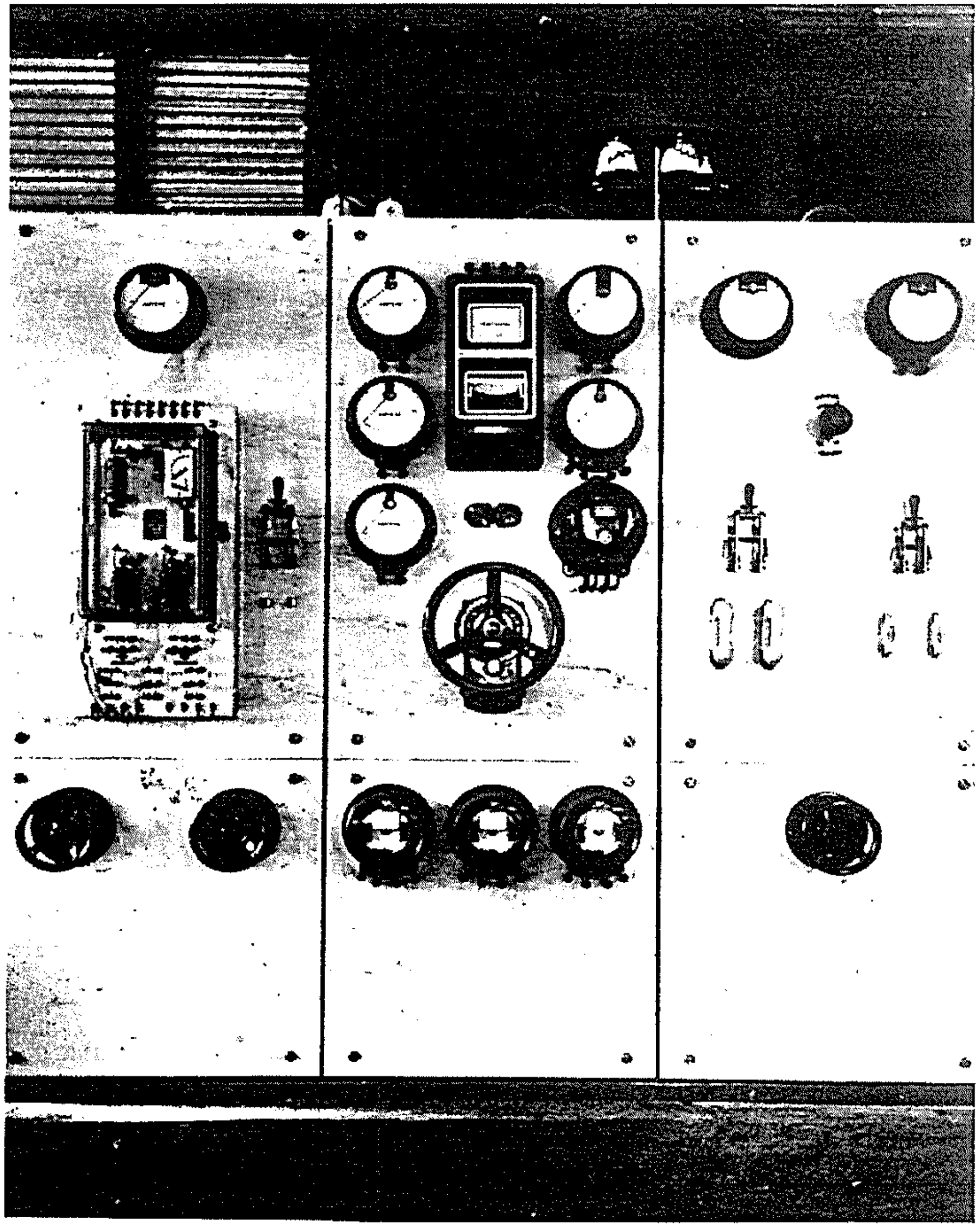
The line surge diverters in their concrete cubicles

Cassilis Hydro-electric Scheme – Image 8



The Voith Hydraulic Governor for the 670 HP Turbine

Cassilis Hydro-electric Scheme – Image 9

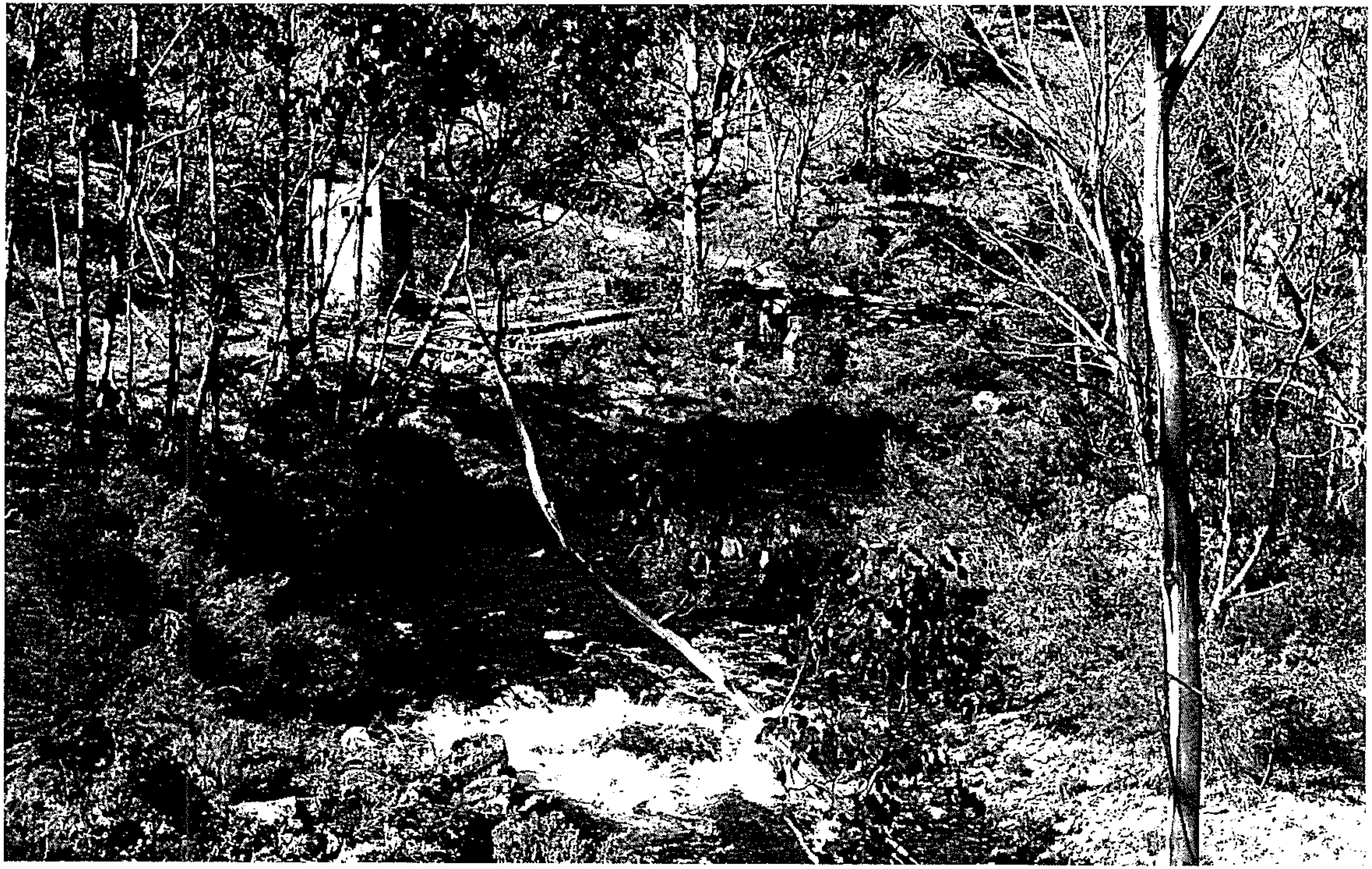


The Marble Switchboard. Tirrell Voltage Regulator on left. Measuring and recording instruments, overload relays and HV circuit breaker operating wheel on centre panel. DC Auxiliary Generator controls on right panel.

# Cassilis Hydro-electric Scheme – Image 10


The completed Power Station in 1908

Cassilis Hydro-electric Scheme – Image 11



1979 photo from the same viewpoint